PB-244 305

PORTABLE AIR COMPRESSOR NOISE

W. N. Patterson, et al

Bolt Beranek and Newman, Incorporated

Prepared for:

Environmental Protection Agency

29 March 1974

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PB244305

Report No. 2795a

PORTABLE AIR COMPRESSOR NOISE

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29 March 1974

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CAMBRIDGE WASHINGTON, D.C. CHICAGO HOUSTON LOS ANGELES SAN FRANCISCO

162

BIBLIOGRAPHIC DATA SHEET

1. Report No.
2795a

2.

PB 244 305

4. Title and Subtitle
Portable Air Compressor Noise

5. Report Date
29 March 1974

6.

7. Author(s)
W. N. Patterson, R. A. Ely, G. G. Huggins

8. Performing Organization Rept. No. 2795a

9. Performing Organization Name and Address
Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

10. Project/Task/Work Unit No.
68-01-2316 (002)

11. Contract/Grant No.
EPA 68-01-1547

12. Sponsoring Organization Name and Address
Environmental Protection Agency
Office of Noise Abatement and Control
Washington. D.C. 20460

13. Type of Report & Period Covered
Final
Jan.-March 1974

14.

15. Supplementary Notes

16. Abstracts The character and magnitude of compressor noise, the technology and cost of quieting compressors, the validity of manufacturers' data, and propagation of compressor noise in the community are examined in this report. It is found that the noise radiated by portable air compressors is typically nondirective (especially by the quieted compressors). The propagation of air compressor noise in the community is best summarized in terms of construction-site geometry. Quieting air compressors alone will not significantly reduce total noise at construction sites. Comparison of 20 construction-site models shows the maximum reduction of total site noise to be less than 2 dB when the air compressor is quieted by 10 dB. Quieting portable air compressors to 76 or 78 dBA (at 7 m) will not alter the operational performance of the machine, if correct design techniques are used. Based on analytical analyses using present noise control technology, it is concluded that quieting air compressors to 65 dBA at 7 m is feasible.

17. Key Words and Document Analysis. 17a. Descriptors

sound power data
sound pressure data
directivity
community noise exposure
canyon effect
construction site configurations and typical equipment mix
overhead noise levels
reverberation effection
ground reflections
comparison of manufacturer data
measurement results
measurement methodologies:
  1) CAGI/PNEUROP
  2) ANSI
  3) ISO

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement
Release unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page
UNCLASSIFIED

21. No. of Pages
162

22. Price
$6.25-2.25

FORM NTIS-35 (REV. 3-72)

THIS FORM MAY BE REPRODUCED

USCOMM-DC 14952-P72

ABSTRACT

The character and magnitude of compressor noise, the technology and cost of quieting compressors, the validity of manufacturers' data in a previous report, and propagation of compressor noise in the community are examined in this report and Report 2795b. It is found that the noise radiated by portable air compressors is typically nondirective (especially by the quieted compressors); i.e., when viewing the compressor from different directions at a radius (including overhead direction), the measured sound levels do not vary significantly. The propagation of air compressor noise in the community is best summarized in terms of construction-site geometry. Quieting air compressors alone will not significantly reduce total noise at construction sites. Comparison of 20 construction-site models shows the maximum reduction of total site noise to be less than 2 dB when the air compressor is quieted by 10 dB. Quieting portable air compressors to Level 1 (76 and 78 dBA at 7 m) will not alter the operational performance of the machine, if correct design techniques are used. It is concluded that quieting air compressors to 65 dBA at 7 m is feasible with present technology, and the customers' cost of quieting listed in the previous report (2566c) is conservative when compared to manufacturers cost of quieting.

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PREFACE

This volume documents the results of a two-month study of portable air compressor noise propagation and measurements for the Environmental Protection Agency under Contract 68-01-1547, Task 68-01-2316(002).

Special thanks and acknowledgement of assistance are offered to the management and staff of the manufacturers listed below who so graciously provided machines, time, and helpful suggestions during the performance of this work.

Atlas Copco Inc.
Gardner-Denver Co.
Ingersoll-Rand Co.
Jaeger Machine Co.
Worthington CEI Inc.

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1. INTRODUCTION

This report provides background information on noise measurement procedures and assesses the accuracy of these procedures in predicting community noise from air compressors. Presently, three similar testing techniques are used to measure the noise levels of air compressors. The most general of these is the CAGI/PNEUROP Test Code, an industry trade-association developed test. The ANSI Standard (Code No. S5.1 1971) has the same text. Finally, there is the ISO-2151-1972 Test Code. All three codes provide for 1- and 7-m measurement positions some prescribed distance above a horizontal plane around the air compressor. We investigated the adequacy of these tests and the influence of an additional overhead measurement on the characterization of air compressor noise. To provide additional information on the accuracy of these procedures in predicting compressor noise in the community, we also determined the directivity and sound power levels of air compressors. We then compared the results with those calculated from results obtained with the various measurement procedures.

Section 2 presents the results of directivity and sound power level calculations for six air compressors. Comparison is made with a similar sound power calculation based on horizontal measurements at 1 and 7 m plus an overhead measurement at 7 m.

In an earlier report (BBN 2566c), the list price increase for quieted air compressors was assessed, using manufacturers' data. The manufacturers' data consisted of sound level and price information. Section 3 compares the results of 26 field tests with the manufacturers' reported data. In addition, Sec. 3 studies the distribution of sound levels among units of

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the same model. An analytic investigation in Sec. 4 deals with community exposure to air compressor noise. Theoretical and empirical models are used to predict the expected influence of construction-site configurations on air compressor noise levels in the community. Section 5 develops a relationship between expected community noise levels and air compressor noise.*

---

*For a Glossary of Technical Terms, See "Portable Air Compressor Noise: Diagnosis and Control" (BBN Report 2795b).

2. DIRECTIVITY AND SOUND POWER OF PORTABLE AIR COMPRESSORS

Predicting community noise levels and the spatial distribution of noise requires information as to the sound power and directivity of the noise source. This section provides sound power levels and directivity calculated from measurements of six portable air compressors, and it compares these results with those obtained by using other measurement procedures.

2.1 Measurement Methodology

Several methods can be used to determine the sound power and directivity of a noise source. Sound power can be found from sound pressure levels measured in anechoic, free-field, or calibrated reverberant spaces. Directivity, however, can be determined only in anechoic or free-field spaces. Since both sound power and directivity were to be determined in this study, measurements in a reverberant space were omitted.

For a simple nondirectional source, sound power, W, can be found from the product of the intensity, I, at the surface of a sphere centered at the source, times the area of the surface, or

$$W = IS \quad . \tag{1}$$

However, when the source is directional, intensity varies over the surface of the sphere. In this case, sound power is found by integrating over the spherical surface:

$$W = \int_S I_s dS \quad , \tag{2}$$

where I_s is the intensity through each differential area, dS.

Sound intensity is difficult to measure directly. Therefore, sound power is usually calculated from a measurement of mean-square sound pressure, which, for a plane wave, is defined by

$$p_{rms}^2 = \rho c I \quad , \tag{3}$$

where ρc is the characteristic impedance of the medium, nominally 406-mks rayls for air.

The directivity of a source is defined in terms of its directivity factor, Q. It is defined as the ratio of (1) the mean-square pressure measured at some point a distance, R, from the source radiating W watts, to (2) p_{rms}^2 at the same distance from an omnidirectional source radiating the same sound power, W.

Sound power level is found from the sound power by

$$PWL = 10 \log \frac{W}{W_0} \quad , \tag{4}$$

where W_0 is a reference sound power, usually 10^{-12} watt.

For the measurements done for this study, the only practical site for field testing is a free-field space over a reflecting plane, e.g., a sealed-asphalt parking lot. In this case, measurements are made on the surface of a hemisphere centered on the source. For our purposes, use of a 10-point* microphone placement on this hemisphere provides an adequate estimate of sound power and directivity. Locations of the noise source and the 10 microphone points are shown in Figs. 1 and 2.

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*Described in General Radio's *Handbook of Noise Measurement* (1972).

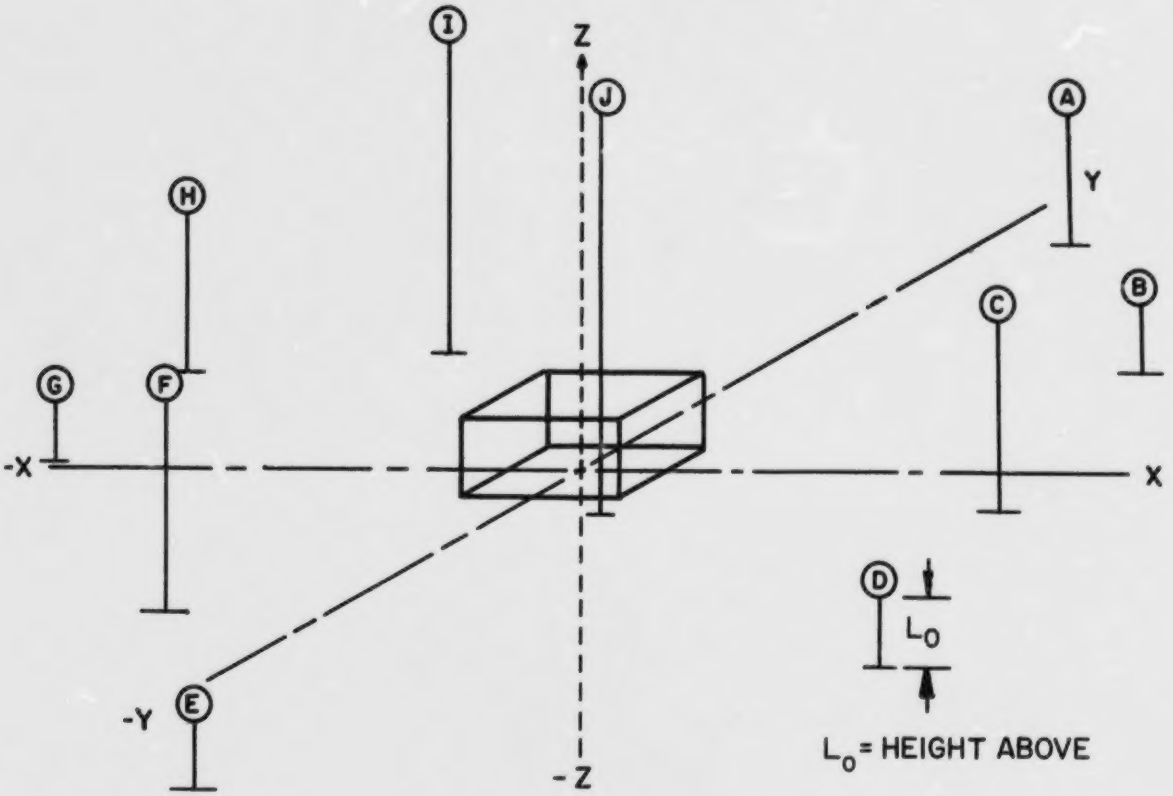
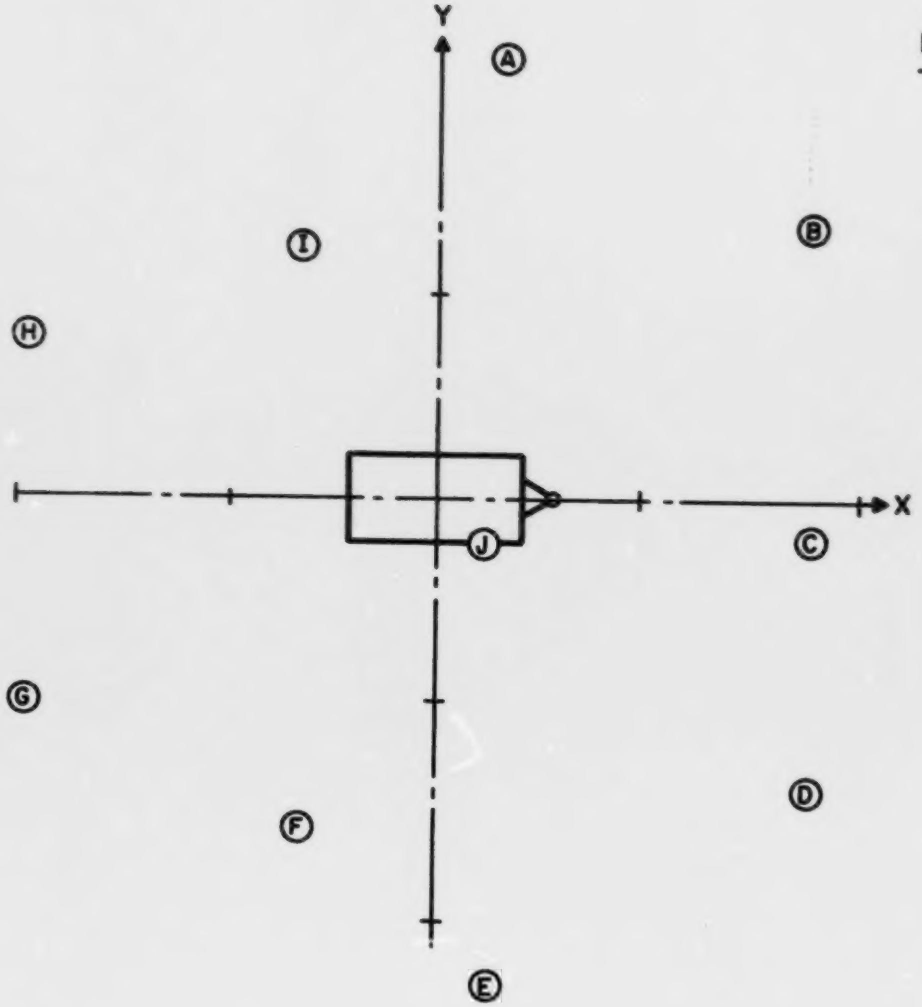

I
Z
J
A
Y
H
B
C
G
F
-X
X
D
L_0
-Y
E
-Z
L_0 = HEIGHT ABOVE

FIG. 1. SCHEMATIC DIAGRAM OF 10 MICROPHONE LOCATIONS.



POSITION	X/R	Y/R	Z/R
A	0.158	0.898	0.410
B	0.775	0.550	0.313
C	0.738	-0.067	0.671
D	0.775	-0.603	0.193
E	0.158	-0.961	0.224
F	-0.257	-0.652	0.713
G	-0.834	-0.399	0.381
H	-0.834	0.315	0.452
I	-0.257	0.498	0.828
J	0.100	-0.099	0.990

FIG. 2. MICROPHONE LOCATIONS FOR 10 POINTS ON HEMISPHERE OF RADIUS R.

The schematic of Fig. 1 shows the source located at the center of the coordinate axes. The 10 microphones are equally spaced on the surface of a hemisphere of radius R (for all measurements but one R was 7 m, R was 10 m for the exception).

The microphones are located according to the Cartesian coordinates given in Fig. 2. Each measurement point is centered at an area on the hemisphere; equal spacing of the microphones provides equal areas. The sound power level calculated from these measurements is 3-dB greater than that for free space, because of the reflecting plane.

When an omnidirectional source is placed at the center of a sphere, the sound power level can be found from the SPL at any point on the sphere, from Eqs. 1, 3, and 4 as

$$\mathrm{PWL} = \mathrm{SPL} + 10 \log S = \mathrm{SPL} + 20 \log R + 11 \quad , \qquad (5)$$

where R is in meters, and SPL is in dB re 20μP. To calculate acoustic power from a directive source, measurements of pressure (or intensity) must theoretically be integrated over the spherical surface, as in Eq. 2. A practical procedure, however, is to use the following formula for n measurements:

$$W = \sum_{i=1}^{n} \bar{I}_i S_i \quad ,$$

where $\bar{I}_i$ is the average intensity over the area S_i. The variation of I_i within S_i should be small, e.g., ± 1 dB. An alternative procedure is to find the average intensity $\bar{I}$ of the n intensities $\bar{I}_i$, and calculate the power from

$$W = \bar{I} S \quad ,$$

where S is the area of the entire sphere. The sound pressure level associated with this average intensity is defined as $\overline{SPL}$.

Therefore, sound power level is found from sound pressure level measurements above a reflecting plane by

$$PWL = \overline{SPL} + 20 \log R + 8 \quad , \qquad (6)$$

where 3 dB has been subtracted from Eq. 5. In a similar fashion, the directivity factor in the *ith* direction is calculated from the average sound pressure level as

$$Q = \text{antilog} \frac{SPL_i - \overline{SPL}}{10} \quad . \qquad (7)$$

Once the sound power and directivity of a noise source are known, the community noise levels from the source may be estimated on the basis of construction site configurations.

2.2 Measurement Results

Directivity and sound power data for six compressor units are listed in Tables 1 through 8. All of the units were measured at a 7-m radius, except the Worthington 750-QTEX, which was measured at a 10-m radius. These compressors are pictured in Appendix C, along with the conventional measurement results per ISO-2151-1972 (CAGI/PNEUROP) with an added overhead measurement. The Gardner-Denver unit was measured at idle as well as at full power. All of the units, except the Ingersoll-Rand DXLCU 1050, are silenced versions. None of the compressors measured displayed any significant directivity.

An additional measurement of directivity in the horizontal plane was obtained on the Ingersoll-Rand DXL 900S unit (Table 6).

TABLE 1. COMPRESSORS TESTED FOR SOUND POWER AND DIRECTIVITY

Manufacturer	Model	Capacity	No.*
Atlas Copco	VSS-170	170-cfm diesel	8
Worthington	160 G/2 QT	160-cfm gasoline	9
Worthington	750-QTEX	750-cfm diesel	10
Ingersoll-Rand	DXLCU 1050	1050-cfm diesel	15
Ingersoll-Rand	DXL 900S	900-cfm diesel	17
Gardner-Denver	SPQDA/2	750-cfm diesel	21

---

*In the table, the numbers for each compressor refer to the identification number assigned in Sec. 3. These compressors are described more fully in Table 10 of Sec. 3.

TABLE 2. DIRECTIVITY AND SOUND POWER OF ATLAS COPCO VSS-170

Position	Radius	Sound Level dBA
A	7 m	71
B		75
C		72
D		72
E		72
F		71
G		71
H		72
I		71
J		70
Average Sound Level, dBA		71.7
A-weighted Power Level, dB re 10^{-12} W		96.7
Maximum Q (directivity factor)		2.14
Direction of Maximum Q		Position B
Minimum Q		0.822
Direction of Minimum Q		Position J

TABLE 3. DIRECTIVITY AND SOUND POWER OF WORTHINGTON 160 MONOROTOR

Position	Radius	Sound Level dBA
A	7 m	77
B		77
C		77
D		77
E		78
F		77
G		78
H		77
I		77
J		76
Average Sound Level, dBA		77.1
A-weighted Power Level, dB re 10^{-12} W		102.1
Maximum Q (directivity factor)		1.23
Direction of Maximum Q		Position E&G
Minimum Q		0.777
Direction of Minimum Q		Position J

TABLE 4. DIRECTIVITY AND SOUND POWER OF WORTHINGTON 750-QTEX

Position	Radius	Sound Level dBA
A	10 m	72
B		72
C		73
D		73
E		71
F		71
G		72.5
H		72.5
I		72
J		72.5
Average Sound Level at 10 m-radius, dBA		72.2
A-weighted Power Level, dB re 10^{-12} W		100.2
Maximum Q (directivity factor)		1.22
Direction of Maximum Q		Position C&D
Minimum Q		0.767
Direction of Minimum Q		Position E&F

TABLE 5. DIRECTIVITY AND SOUND POWER OF I-R DXLCU 1050

Position	Radius	Sound Level dBA
A	7 m	92
B		94.5
C		93
D		94.5
E		94.5
F		93
G		91
H		91.5
I		92
J		89
Average Sound Level, dBA		92.5
A-weighted Power Level, dB re 10^{-12} W		117.5
Maximum Q (directivity factor)		1.58
Direction of Maximum Q		Positions B,D,E
Minimum Q		0.446
Direction of Minimum Q		Position J

TABLE 6. DIRECTIVITY AND SOUND POWER OF I-R DXL 900S

Position	Radius	Sound Level dBA
A	7 m	77.5
B		76.5
C		80
D		77.5
E		78
F		80.5
G		81
H		81
I		79
J		78
Average Sound Level, dBA		78.9
A-weighted Power Level dB re 10^{-12} W		103.9
Maximum Q (directivity factor)		1.62
Direction of Maximum Q		Positions G&H
Minimum Q		0.575
Direction of Minimum Q		Position B

TABLE 7. DIRECTIVITY AND SOUND POWER OF GARDNER-DENVER SPQDA/2 750-cfm COMPRESSOR AT FULL POWER

Position	Radius	Sound Level dBA
A	7 m	81
B		80.5
C		77
D		78.5
E		79
F		79.5
G		80.5
H		81
I		80.5
J		77
Average Sound Level, dBA		79.5
A-weighted Power Level dB re 10^{-12} W		104.5
Maximum Q (directivity factor)		1.43
Direction of Maximum Q		Positions A&H
Minimum Q (directivity factor)		0.754
Direction of Minimum Q		Positions C&J

TABLE 8. DIRECTIVITY AND SOUND POWER OF GARDNER-DENVER SPQDA/2 750-cfm COMPRESSOR AT IDLE

Position	Radius	Sound Level dBA
A	7 m	76
B		75.5
C		69.5
D		70
E		71
F		72.5
G		72
H		74
I		72
J		72
Average Sound Level, dBA		72.5
A-weighted Power Level dB re 10^{-12} W		97.5
Maximum Q (directivity factor)		2.26
Direction of Maximum Q		Position A
Minimum Q (directivity factor)		0.507
Direction of Minimum Q		Position C

Noise levels were taken at 30°-increments and at 7 m from the surface of the compressor, following the CAGI/PNEUROP technique. Figure 3 shows the A-weighted noise level contour. Note the nondirectional character of the data.

The average level of the four cardinal points for this unit (see Appendix C) is 75.3 dBA. This is almost identical to the average of 75.4 dBA for all 12 points of Fig. 3. In comparison, the average of the 10 points on the hemisphere about the DXL 900S unit (at 7 m from the ground plane coordinate axes rather than from the compressor surface) is 78.9 dBA (from Table 6). Since this unit is 2.3-m wide by 4.5-m long, the CAGI/PNEUROP data are taken, on the average, nearly 2-m further from the machine. For spherical spreading, this is a correction factor of about 3 dB, which reduces the average hemispherical SPL to about 76 dBA. This level correlates well with the 75.3- and 75.4-dBA averages obtained 7 m from the surface.

2.3 Comparison of Sound Power Calculations

To determine the adequacy of the ISO-2151-1972, ANSI S5.1-1971, and CAGI/PNEUROP test methods for characterizing portable air compressor noise in the community, we compare sound power levels calculated from the results of these measurement procedures to power levels calculated from the 10-point hemispherical data reported in Sec. 2.2. These comparisons are made using (1) the four 7-m measurements along the cardinal indices of the compressor, and (2) the 7-m overhead measurement in addition to the previous four. Sound power levels cannot be calculated using the 1-m data, since these are within the geometric near field and the hydrodynamic near field below a few hundred Hertz. The utility of the 1-m levels is assessed in Sec. 2.4.

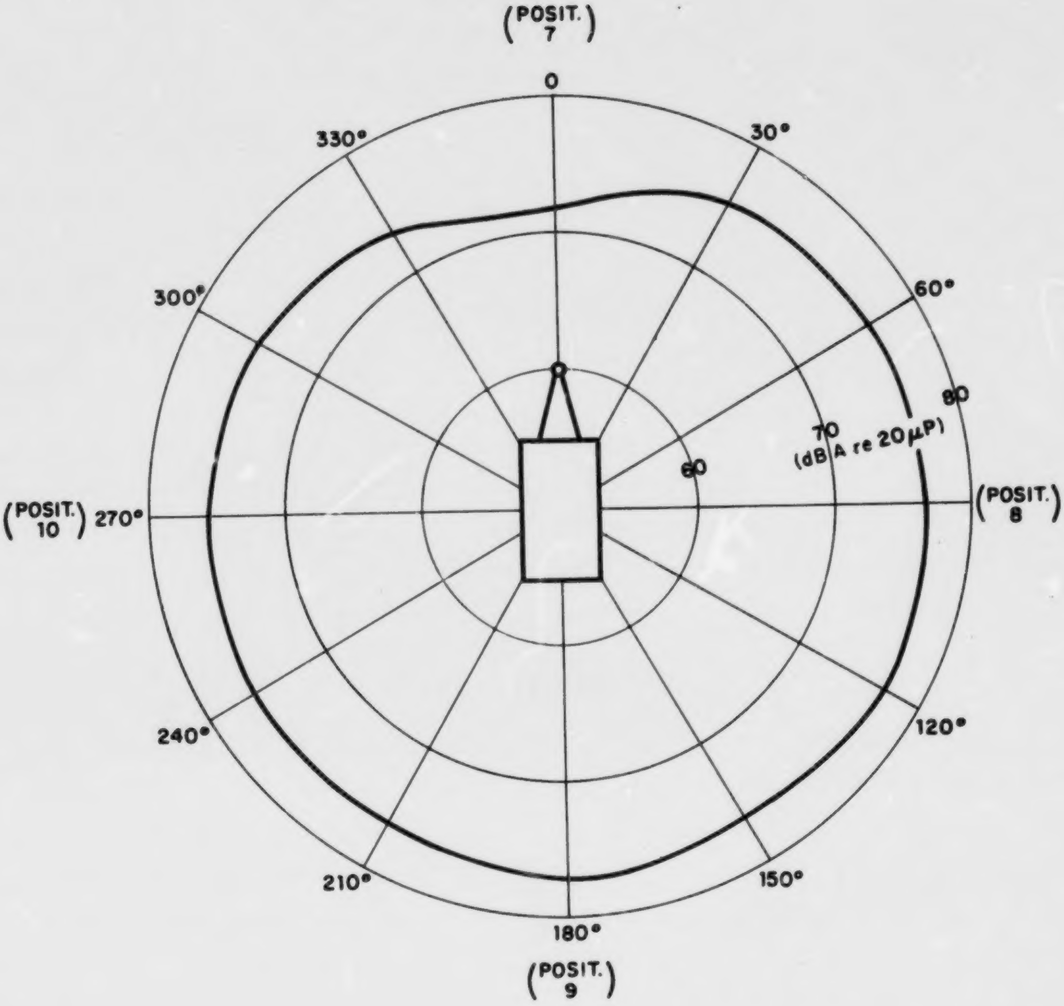


FIG. 3. HORIZONTAL DIRECTIVITY OF INGERSOLL-RAND DXL 900S COMPRESSOR PER CAGI/PNEUROP PLUS ADDED POINTS.

The ISO, ANSI, and CAGI/PNEUROP procedures specify the 7-m measurement points to be 7 m from the surface of the compressor, rather than its geometric center. This difference must be accounted for when determining sound power. The distance from the geometric center for the horizontal measurements is 7 m plus one-half of either the length (l) or width (w) of the compressor. For the overhead measurement, the distance is 7 m plus the height (h).

In order to calculate the sound power level using the 7-m SPL data from the ISO, ANSI, or CAGI/PNEUROP tests, the sound pressure levels must first be corrected to one constant radius (i.e., to points on one common hemisphere). From these corrected levels, the average SPL is then computed and used in Eq. 6. For purposes of comparison, we correct all sound pressure levels to a radius of 7 m from the geometric center of the machine. That is, for each position

$$SPL_7 = SPL + 20 \log \frac{7+d}{7} \quad , \qquad (8)$$

where SPL_7 is the 7-m level, SPL is the measured level, and

$$d = \begin{cases} l/2, & \text{for end measurements} \\ w/2, & \text{for side measurements} \\ h, & \text{for overhead measurements} \end{cases}$$

d is in meters.

The results of the comparisons are given in Table 9, which lists: (1) the dimensions of the seven compressors; (2) the CAGI sound pressure levels corrected to 7 m from the geometric center of the machine; (3) sound power levels for the 4-, 5-, and 10-point measurements; and (4) the difference in the sound power levels. These differences are summarized in Fig. 4.

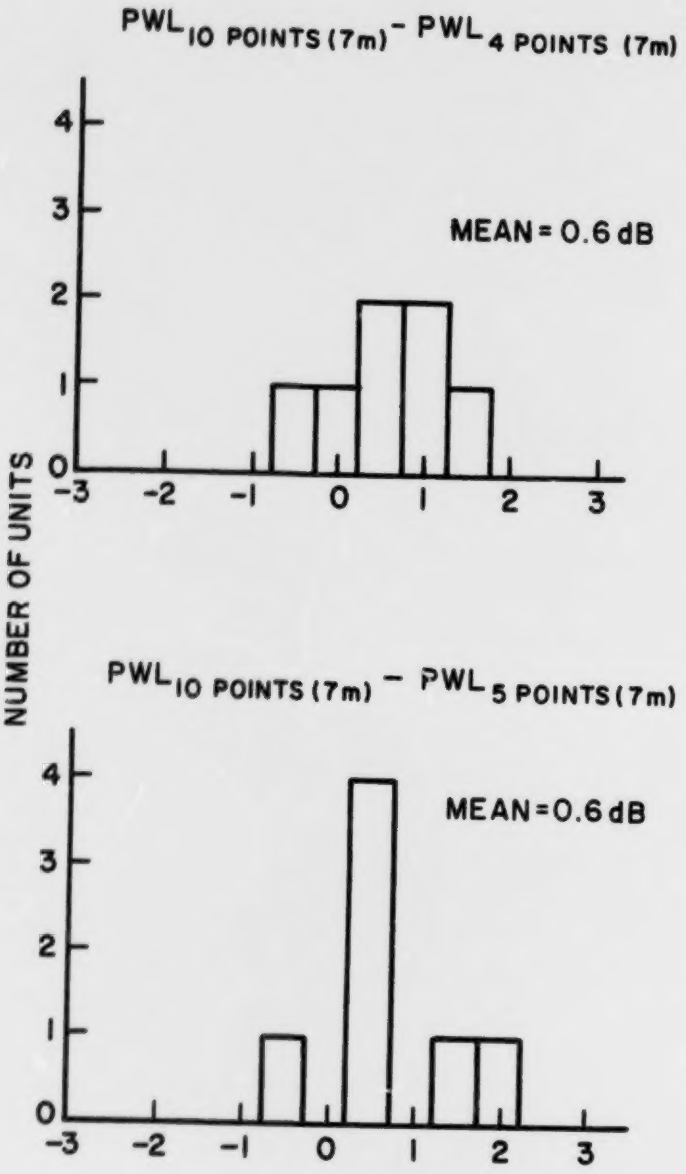


FIG. 4. DIFFERENCES IN SOUND POWER LEVELS.

TABLE 9. SOUND POWER COMPARISONS: HEMISPHERICAL MEASUREMENTS VS CAGI TEST DATA AT 7 M.

Compressor	Length (m)	Width (m)	Height (h)	Corrected CAGI Avg. SPL (dBA) $\overline{SPL}_7$ (4 pt.)	Corrected CAGI Avg. SPL (dBA) $\overline{SPL}_7$ (5 pt.)	$\overline{SPL}$ 10 pt. (dBA)
Atlas Copco VSS 170	1.8	1.7	2.0	71.4	71.3	71.7
Worthington 160 QT	2.4	1.6	1.7	75.9	75.5	77.1
Worthington 750-QTEX	4.4	2.0	2.1	74.9	74.9	72.2*
Ingersoll-Rand DXLCU 1050	4.4	2.2	2.3	92.4	92.2	92.5
Ingersoll-Rand DXL 900S	4.7	2.3	2.6	77.2	77.1	78.9
Gardner-Denver SPQDA/2 (Full Power)	4.3	2.0	2.3	80.0	80.1	79.5
Gardner-Denver SPQDA/2 (Idle)	4.3	2.0	2.3	71.6	72.1	72.5

Compressor	PWL (4 pt.) (dBA)	PWL (5 pt.) (dBA)	PWL (10 pt.) (dBA)	PWL_{10} minus PWL_4	PWL_{10} minus PWL_5
Atlas Copco VSS 170	96.4	96.3	96.7	0.3	0.4
Worthington 160 QT	100.9	100.5	102.1	1.2	1.6
Worthington 750-QTEX	99.9	99.9	100.2	0.3	0.3
Ingersoll-Rand DXLCU 1050	117.4	117.2	117.5	0.1	0.3
Ingersoll-Rand DXL 900S	102.2	102.1	103.9	1.7	1.8
Gardner-Denver SPQDA/2 (Full Power)	105.0	105.1	104.5	-0.5	-0.6
Gardner-Denver SPQDA/2 (Idle)	96.6	97.1	97.5	0.9	0.4

*These levels were taken at 10 m from the geometric center. All others were at 7 m.

The results show that power levels calculated from the CAGI/PNEUROP 4-point and 5-point data compare well to the more precise 10-point hemispherical measurements. An average difference of only 0.6 dB was found in each case. These results primarily occurred because the compressors tested were not very directive. In the extreme case of a completely nondirective compressor, all methods would yield exactly the same results; in fact, only one SPL measurement would be required. The accuracy of calculating sound power from CAGI/PNEUROP data will become progressively worse for compressors with greater directivity.

2.4 Assessment of One-Meter Data

Each of the ISO, ANSI, and CAGI/PNEUROP tests call for measurements at 1 m from the surface of the compressor. In Sec. 2.3, it was stated that these data cannot be employed to calculate sound power because the microphone is in the near field of the compressor, i.e., both the geometric and hydrodynamic (acoustic) near fields. To compute sound power level from measured sound pressure level, an expression such as Eq. 6 is required. Equation 6, however, is invalid when the sound field is not composed of spherically spreading waves; i.e., when SPL does not decrease with distance as the familiar 20 log R.

One way to verify that the 1-m data are taken in the near field is to compare 1- and 7-m levels. A histogram of the difference in these levels is presented in Fig. 5 for the 26 compressors that were measured. This figure clearly shows negligible correlation between the two sets of measurements. Spherical spreading of the sound field between 1 and 7 m would yield a 17-dB difference between these points. No compressor showed this large a decrease; moreover, the differences are randomly spread from 5 to 15 dB.

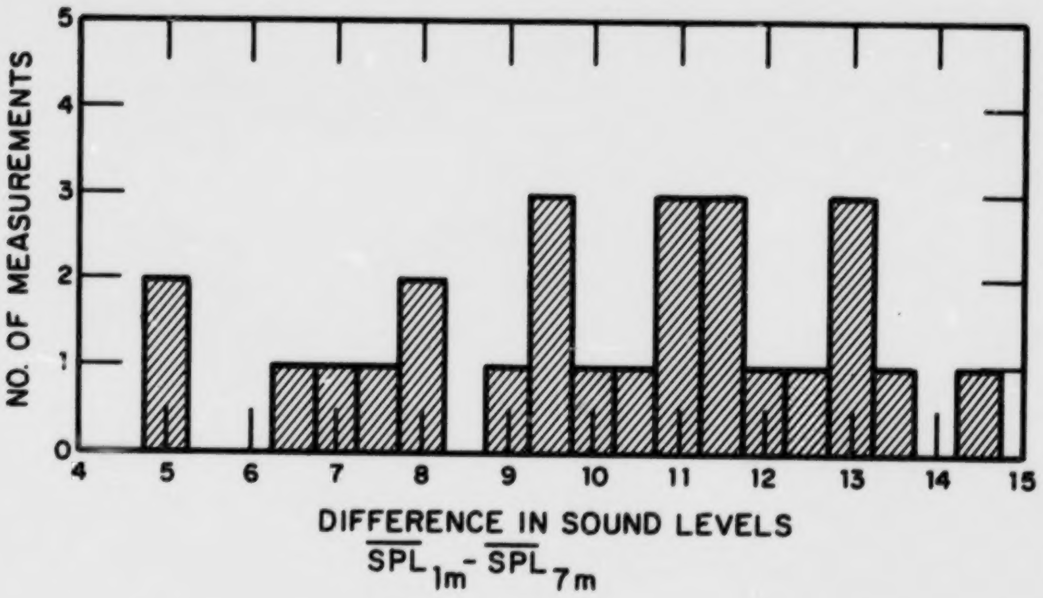


FIG. 5. COMPARISON BETWEEN 7-M AND 1-M CAGI/PNEUROP AVERAGE SOUND LEVELS (AVERAGE OF FIVE MEASUREMENT POINTS).

The above results show that the magnitudes of the 1-m levels are useless in calculating sound power or in assessing community noise. To see if 1-m data are useful in determining the noisiest side of the machine, the three-dimensional histogram of Fig. 6 was derived. The loudest side at 7 m is plotted against the noisiest side at 1 m in this figure.* Again, the 1-m data show poor correlation with 7-m data, in that in half the cases the noisiest direction is incorrectly indicated. Good correlation would place most of the measurements on the diagonal line in Fig. 6.

The most probable reason for the results in Figs. 5 and 6 is that the 1-m levels are being dominated by noise very local to the microphone. Noise emanating from the compressor relatively distant from this microphone contributes to the 7-m microphone, but not to the closer one. This is exactly what occurs in the geometric near field, and it can produce incorrect levels as well as errors in the direction of maximum noise radiation.

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*The abscissa in Fig. 6 use the following convention: 0° is the forward direction, with angular position measured clockwise looking down on the compressor (see Appendix C).

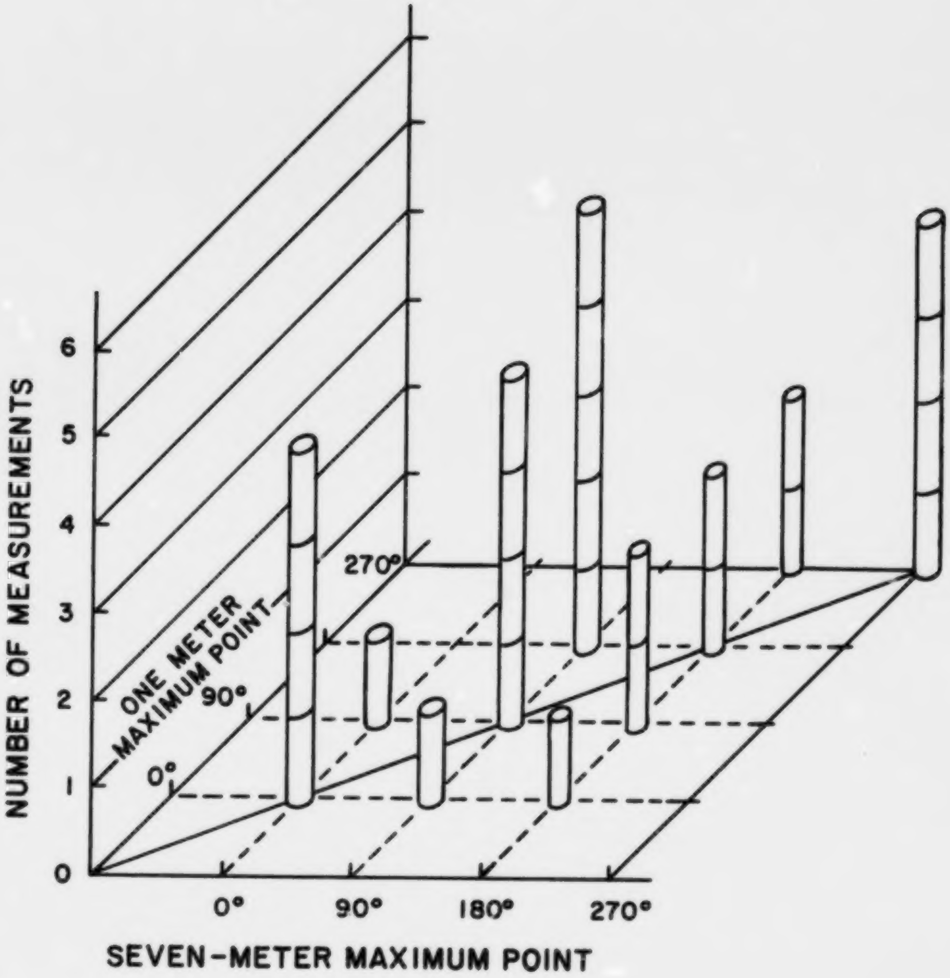

FIG. 6. HISTOGRAM COMPARING MAXIMUM POINT AT 7-M AND 1-M DISTANCES.

3. MEASUREMENTS OF AIR COMPRESSORS CURRENTLY PRODUCED

3.1 Introduction

To provide an independent measure of air compressor noise levels for comparison with manufacturers' data, we measured 23 portable air compressors. Three units were measured with doors open, as well as closed, yielding 26 measurements in all. For the most part, measurements were made at manufacturers' facilities.

3.2 Description of Units Measured

The units were made by five manufacturers: Atlas Copco, Worthington, Ingersoll-Rand, Gardner-Denver, and Jaeger (see Table 10). Four nominally identical units on an Ingersoll-Rand silenced model (DXL 900S, a 900-cfm machine) were included in this sample. Nine of the units were standard and 14 were silenced versions. Five had gasoline engines; the rest were diesel powered. Table 11 provides further information about the engines.

3.3 Measurement Results

The CAGI/PNEUROP measurement technique was used with one modification: the addition of a measurement 7 m above the compressor surface. A comprehensive listing of the data gathered is given in Appendix C. An example of the formatting of the data is given in Figs. 7a and 7b for unit No. 1, an Atlas Copco Model ST-48, 160-cfm capacity. Figure 7a shows the compressor, describes the unit and its engine, and reports the 1-m levels taken at positions 2, 3, 4, and 5, in the diagram to the right of Fig. 7b. For all models tested, the microphone picking up the highest noise levels was always located at one of the four

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MANUFACTURER: ATLAS COPCO

COMPRESSOR

Type: Reciprocal
Model: ST-48
Serial: 51232751
Capacity: 160 cfm, 100 psi

ENGINE

Make: Deutz F4L 912
Horsepower: 50
Rated Speed: 1750 rpm

Test Date: 1/25/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 1-2 mph
Temperature: 45° F

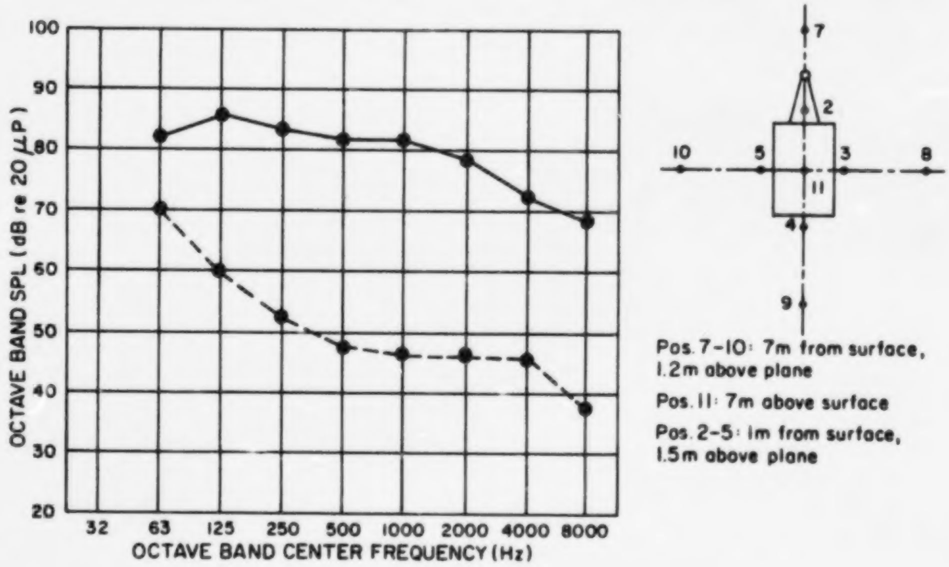
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	81	87	88	81
	Linear	94.5	97	97.5	97
Full Power	dBA	95.5	98	99	94
	Linear	104	104	103	102.5

FIG. 7a. EXAMPLE OF REPORTING FORMAT.

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	72	75	74	82	77	
	Linear	83	87	86	87	88	
Full Power	dBA	84	83	86	82	83	55
	Linear	92	93	91	92.5	92	71
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	90	89	82	89	89	70
	125	80	87	85	86.5	85	60
	250	79	80	84	82	83	53
	500	82	78	82	78	78	48
	1000	81	79	82	78	75	47
	2000	75	76	79	75	75	45
	4000	69	69	72	63	68	45
	8000	66	67	69	63	64	38



Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

FIG. 7b. EXAMPLE OF REPORTING FORMAT.

TABLE 10. COMPRESSORS TESTED: COMPRESSOR INFORMATION.

No.	Manufacturer	Model	Silenced or Standard	Type	Serial	Capacity (cfm,psi)
1	Atlas Copco	ST-48	Standard	Reciprocal	51232751	160,100
2	Atlas Copco	ST-95	Standard	Reciprocal	51274977	330,105
3	Atlas Copco	VSS-170 Dd	Silenced	Reciprocal	51235072	170,85
4	Atlas Copco	VT-85 Dd	Standard	Reciprocal	ARP203149	85,100
5	Atlas Copco	VS-85 Dd	Silenced	Reciprocal	ARP203903	85,100
6	Atlas Copco	VSS-125 Dd	Silenced	Reciprocal	51345060	125,100
7	Atlas Copco	STS-35 Dd	Silenced	Reciprocal	ARP550924	125,100
8	Atlas Copco	VSS-170 Dd	Silenced	Reciprocal	51235072	170,100
9	Worthington	160 G/2 QT	Silenced	Vane	821-478	160,100
10	Worthington	750-QTEX	Silenced	Rotary-Screw	848-019	750,100
11	Ingersoll-Rand	DXL 1200	Standard	Rotary-Screw	74430	1200,125
12	Ingersoll-Rand	DXL 1200 **doors open**	Standard	Rotary-Screw	74430	1200,125
13	Ingersoll-Rand	DXL 900S	Silenced	Rotary-Screw	73693	900,125
14	Ingersoll-Rand	DXL 900S	Silenced	Rotary-Screw	74050	900,125
15	Ingersoll-Rand	DXL CU1050	Standard	Rotary-Screw	75613	1050,125
16	Ingersoll-Rand	DXL 900S	Silenced	Rotary-Screw	74051	900,125
17	Ingersoll-Rand	DXL 900S	Silenced	Rotary-Screw	740471	900,125
18	Ingersoll-Rand	DXL 900	Standard	Rotary-Screw	75847	900,125
19	Ingersoll-Rand	DXL 750	Standard	Rotary-Screw	77380	750,125
20	Gardner-Denver	SPWDA/2	Silenced	Rotary-Screw	635851	1200,100
21	Gardner-Denver	SPQDA/2	Silenced	Rotary-Screw	608227	750,100
22	Gardner-Denver	SPHGC	Silenced	Rotary-Screw	629717	185,100
23	Jaeger	A	Standard	Rotary-Screw	RS-32189	175,100
24	Jaeger	A **doors open**	Standard	Rotary-Screw	RS-32189	175,100
25	Jaeger	E	Standard	Vane	RC-32032	85,100
26	Jaeger	E **doors open**	Standard	Vane	RC-32032	85,100

TABLE 11. COMPRESSORS TESTED: ENGINE INFORMATION.

No.	Manufacturer	Model	Engine	Power (hp)	Rated Speed (rpm)
1	Atlas Copco	ST-48	Deutz F4L912	50	1750
2	Atlas Copco	ST-95	Deutz BF6L913	93	1750
3	Atlas Copco	VSS-170 Dd	Deutz F4L912	50	1750
4	Atlas Copco	VT-85 Dd	Deutz F4L912	50	1750
5	Atlas Copco	VS-85 Dc	Deutz F2L912	25	1800
6	Atlas Copco	VSS-125 Dd	Deutz F3L919	37	1750
7	Atlas Copco	STS-35 Dd	Deutz F3L912	40	1750
8	Atlas Copco	VSS-170 Dd	Deutz F4L912	50	1750
9	Worthington	160 G/2 QT	IH (Gas)	65	2400
10	Worthington	750-QTEX	GMDD 6V-71	210	2100
11	Ingersoll-Rand	DXL 1200	GMDD 12V-71N	420	2100
12	Ingersoll-Rand	DXL 1200 doors open	GMDD 12V-71N	420	2100
13	Ingersoll-Rand	DXL 900S	GMDD 8V-71N	280	2100
14	Ingersoll-Rand	DXL 900S	GMDD 8V-71N	280	2100
15	Ingersoll-Rand	DXL CU1050	Cummins V-903	307	2600
16	Ingersoll-Rand	DXL 900S	GMDD 8V-71N	280	2100
17	Ingersoll-Rand	DXL 900S	GMDD 8V-71N	280	2100
18	Ingersoll-Rand	DXL 900	GMDD 8V-71N	280	2100
19	Ingersoll-Rand	DXL 750	GMDD 6V-71N	228	2100
20	Gardner-Denver	SPWDA/2	GMDD 12V-71N	400	1850
21	Gardner-Denver	SPQDA/2	GMDD 6-71N	228	2100
22	Gardner-Denver	SPHGC	Ford (Gas) 6 Cyl.	82	2400
23	Jaeger	A	White (Gas)	76	2200
24	Jaeger	A doors open	White (Gas)	76	2200
25	Jaeger	E	IH (Gas)	46.5	2050
26	Jaeger	E doors open	IH (Gas)	46.5	2050

cardinal points: positions 2, 3, 4, or 5 for 1-m measurements and positions 7, 8, 9, or 10 for 7-m measurements. Therefore, positions 1 and 6 were eliminated from consideration; position 11 is the overhead 7-m measurement. The table at the top of Fig. 7b reports the 7-m measurements. The table includes A-weighted sound levels at idle and full power and octave band sound pressure levels at full power. At the bottom of this figure, the octave band spectrum is plotted for the noisiest of the five 7-m positions. A curve of background ambient levels measured at one of positions 7 through 10 is also given.

The data given in Appendix C are summarized in Table 12. The 7-m CAGI/PNEUROP levels are the average of five measurement points. The loudest measurement (from position 7, 8, 9, or 10) was used twice in the averaging; thus, for each unit, the average is for five data points. The column in this table labeled 7-m Modified CAGI/PNEUROP adds a sixth data point to the average: the overhead level at position 11.

Figure 8 gives a plot of the sound levels measured at 7 m per CAGI/PNEUROP test method for the 23 compressors as a function of their capacity in cfm. Looking at the differences among standard and silenced models, we see that noise levels from silenced models tend to group into a band from about 70 to 78 dBA; the noisier of these silenced models are those with higher capacity. On the whole, the standard models emit levels some 10- to 10-dBA greater than the silenced compressors, spanning a range of about 80 to 95 dBA; the standard models also show a greater increase in noise with increase in capacity than do the silenced units.

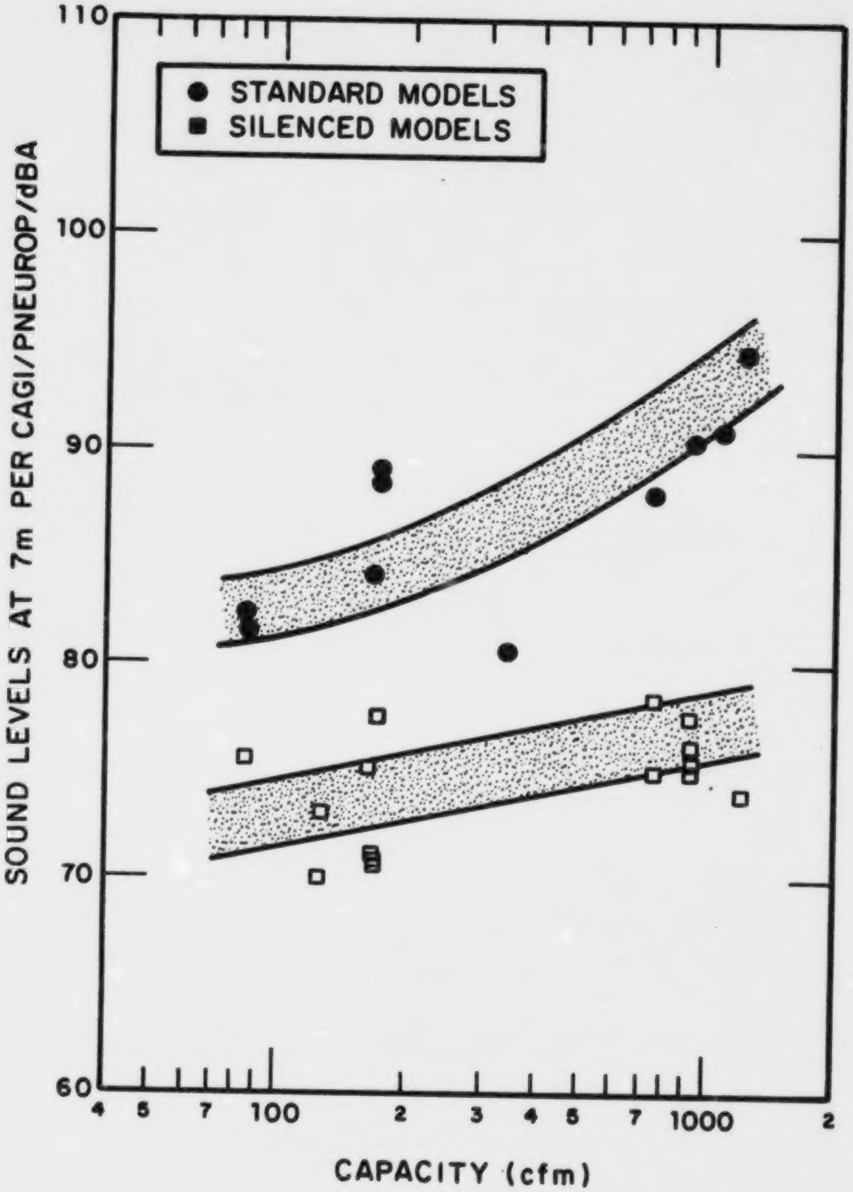


FIG. 8. SEVEN-METER CAGI/PNEUROP LEVELS AS A FUNCTION OF COMPRESSOR CAPACITY.

TABLE 12. SUMMARY OF MEASUREMENT RESULTS (dBA).

No.	Manufacturer	Model	Capacity (cfm)	7-m CAGI/PNEU.	7 m-Mod. CAGI/PNEU.	Overhead
1	Atlas Copco	ST-48	160	84	84	83
2	Atlas Copco	ST-95	330	80.5	80.5	79.5
3	Atlas Copco	VSS-170 Dd	170	71	70.5	68
4	Atlas Copco	VT-85 Dd	85	82.5	82	79
5	Atlas Copco	VS-85 Dd	85	75.5	76	76
6	Atlas Copco	VSS-125 Dd	125	70	70	72.5
7	Atlas Copco	STS-35 Dd	125	73	73.5	77
8	Atlas Copco	VSS-170 Dd	170	71	70.5	68.5
9	Worthington	160 G/2 QT	160	75	74.5	72
10	Worthington	750-QTEX	750	75	75	73.5
11	Ingersoll-Rand	DXL 1200	1200	94.5		
12	Ingersoll-Rand	DXL 1200 doors open	1200	96.5		
13	Ingersoll-Rand	DXL 900S	900	77.5	77.5	75
14	Ingersoll-Rand	DXL 900S	900	75.5	75.5	74.5
15	Ingersoll-Rand	DXL CU1050	1050	91	90.5	89
16	Ingersoll-Rand	DXL 900S	900	76	75.5	73.5
17	Ingersoll-Rand	DXL 900S	900	75.5	75.5	74
18	Ingersoll-Rand	DXL 900	900	90.5	90	89
19	Ingersoll-Rand	DXL 750	750	88	88	88
20	Gardner-Denver	SPWDA/2	1200	74	74	73
21	Gardner-Denver	SPQDA/2	750	78.5	78.5	78
22	Gardner-Denver	SPHGC	185	77.5	77	75
23	Jaeger	A	175	88.5	88.5	88
24	Jaeger	A doors open	175	89	89	89.5
25	Jaeger	E	85	81.5	82	84
26	Jaeger	E doors open	85	82	82.5	85

Data on the four Ingersoll-Rand Model DXL 900S units are summarized in Table 13. Individual differences in sound level at each position show a spread of at most ± 1 dB over the five measurement positions. When these data are averaged per CAGI/PNEUROP, the spread in sound levels is 2 dB.*

3.4 Comparison to Manufacturers' Data

CAGI/PNEUROP test procedure levels as measured by BBN and as reported by manufacturers are given in Fig. 9 as a histogram of the difference in levels. Although both the mean and the median of the difference between BBN and manufacturers' data are 0 dBA, there is a wide deviation. Differences of up to 5 dBA were found, giving a standard deviation of 2.3 dBA.

Past history of testing shows that doors open is the normal operating condition for standard units. Since the measurements on standard units were taken by BBN with doors closed, and possibly by the manufacturer with doors opened, these data may be somewhat biased. Therefore, Fig. 10 gives a second histogram for silenced models only (i.e., doors always closed). Both the mean and median are, again, approximately 0 dB. The distribution, however, is significantly tighter, yielding standard deviation of 1.5 dBA.

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*This maximum spread would be 1.5 dB if a true energy average was calculated, rather than following the CAGI/PNEUROP technique: this is because positions 7 to 10 have a greater than 5-dB variation for the first compressor in Table 12. Thus, 1 dB is added to the dB arithmetic average.

TABLE 13. RESULTS OF BBN MEASUREMENTS OF INGERSOLL-RAND DXL 900S (SILENCED) COMPRESSOR MODELS (dBA)

Serial No.	Measurement Position 7	8	9	10	11
73693	73	76.5	78.5	77	75
74050	72.5	75.5	76.5	76.5	74.5
74041	73	76.5	77	76.5	73.5
740471	72	76.5	77	75.5	74

Serial No.	Averaged Per CAGI/PNEU.	Mod. CAGI/PNEU.*
73693	77.5	77.5
74050	75.5	75.5
74041	76	75.5
740471	75.5	75.5

*Average includes overhead measurement.

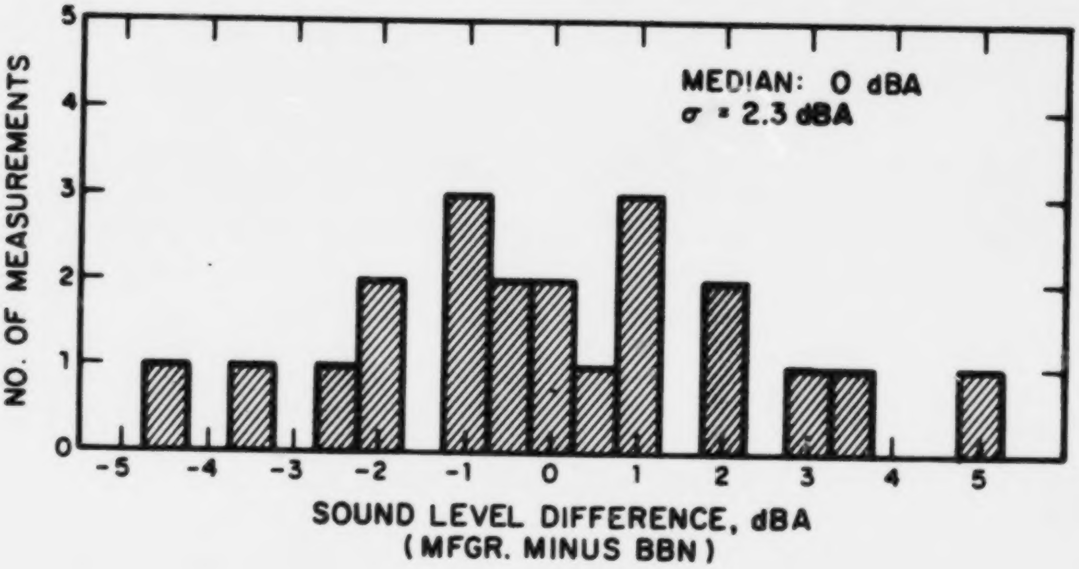

FIG. 9. COMPARISON BETWEEN MANUFACTURER-SUPPLIED LEVELS AND DATA TAKEN BY BBN PER ISO-2151-1972.

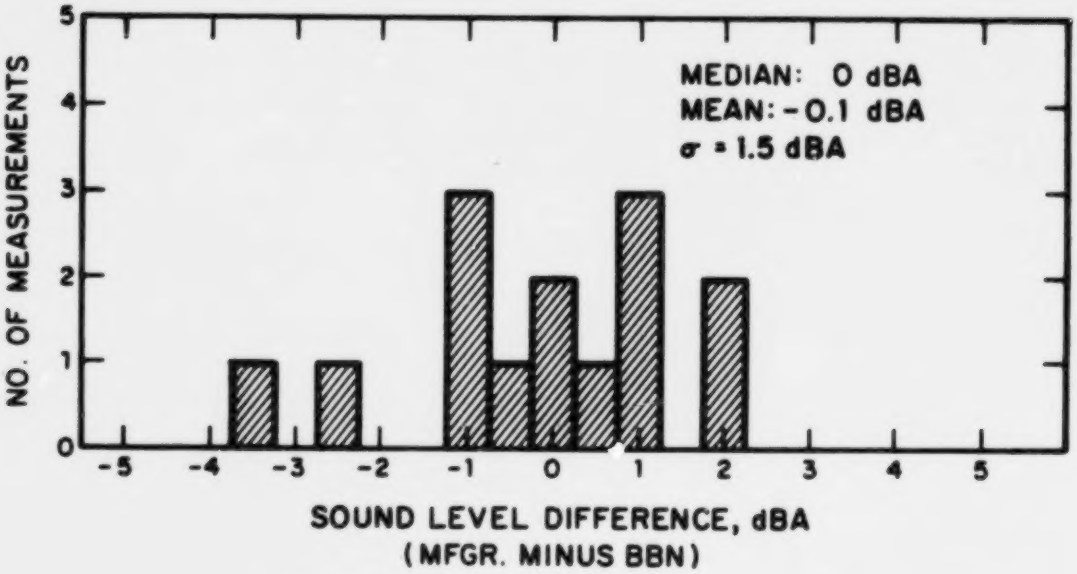

FIG. 10. COMPARISON BETWEEN MANUFACTURER-SUPPLIED LEVELS AND DATA TAKEN BY BBN: SILENCED MODELS ONLY PER ISO-2151-1972.

4. COMMUNITY EXPOSURE TO AIR COMPRESSOR NOISE

Air compressors are included in equipment groupings at construction sites scattered throughout a community. EPA (1971) defined the required equipment groupings in terms of the 20 combinations of construction sites and construction phases shown in Table 14, which applies equally to construction of buildings, city streets, and public works. EPA (1971) also defined typical mixes of equipment, equipment noise levels, and duration of equipment operation for the 20 construction site scenarios. Table 15 shows the types and modes of equipment operation for the 20 scenarios.

Table 15 (a-t) shows that many machines contribute high noise levels to the overall noise at the 20 construction site scenarios. Quieting of the noisiest two or three machines generally produces negligible lowering of the overall noise heard in the community. Each machine must be quieted to a level that is well below the maximum noise level in order for the overall noise to be barely below the maximum allowable level.

TABLE 14. CONSTRUCTION-SITE SCENARIOS

Location	Residential	Commercial	Industrial	Public Works
Clearing	1(a)*	6(f)	11(k)	16(p)
Excavation	2(b)	7(g)	12(l)	17(q)
Foundation	3(c)	8(h)	13(m)	18(r)
Erection	4(d)	9(i)	14(n)	19(s)
Cleanup	5(e)	10(j)	15(o)	20(t)

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*The letters refer to individual tables in Table 15(a-t).

TABLE 15

EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR 20 CONSTRUCTION-SITE SCENARIOS

TABLE 15a. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR RESIDENTIAL CLEARING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Backhoe	85	1	0.02	68
Dozer	87	1	0.1	77
Generator	78	1	0.4	74
Grader	85	1	0.05	72
Loader	79	1	0.2	72
Scraper	88	1	0.05	75
Truck	88	1	0.04	74
Total Site 8-hr L_{EQ}				82.3
With Truck Quieted to 75 dBA				81.6

TABLE 15b. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR RESIDENTIAL EXCAVATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Air compressor	81	1	0.1	71
Backhoe	85	1	0.2	78
Dozer	87	1	1.0	87
Loader	79	1	1.0	79
Pump	76	1	0.1	66
Rock drill	98	1	0.005	75
Shovel	82	1	0.2	75
Truck	88	1	0.1	78
Total Site 8-hr L_{EQ}				89.0
With Truck Quieted to 75 dBA				88.7
With Air Compressor Quieted to 71 dBA (76 dBA at 7 m)				88.9

TABLE 15c. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR RESIDENTIAL FOUNDATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.1	71
Concrete mixer	85	1	0.4	81
Pneumatic tool	85	1	0.04	71
Pump	76	1	0.2	69
Saw	78	2	0.04	67
Total Site 8-hr L_{EQ}				82.1
With Truck Quieted to 75 dBA (includes concrete mixer)				76.9
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				81.8

TABLE 15d. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR RESIDENTIAL ERECTION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.2	73
Concrete mixer	85	1	0.08	74
Crane, mobile	83	1	0.1	73
Pneumatic tool	85	1	0.1	75
Saw	78	2	0.1	71
Total Site 8-hr L_{EQ}				80.4
With Truck Quieted to 75 dBA (includes concrete mixer)				79.4
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				79.6

TABLE 15e. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR RESIDENTIAL FINISHING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.25	75
Backhoe	85	1	0.02	68
Concrete mixer	85	1	0.16	77
Crane, mobile	83	1	0.04	69
Dozer	87	1	0.04	73
Grader	85	1	0.02	68
Jackhammer	88	1	0.01	68
Loader	79	1	0.04	65
Paver	89	1	0.025	73
Pneumatic tool	85	1	0.04	71
Roller	74	1	0.04	61
Saw	78	2	0.04	67
Scraper	88	1	0.01	68
Truck	88	1	0.04	74
Total Site 8-hr L_{EQ}				83.0
With Truck Quieted to 75 dBA (includes concrete mixer)				81.2
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				82.3

TABLE 15f. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR COMMERCIAL CLEARING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Backhoe	85	1	0.04	71
Dozer	87	1	0.16	79
Generator	78	2	0.4	77
Grader	85	1	0.08	74
Loader	79	1	0.16	71
Scraper	88	1	0.55	85
Truck	88	2	0.16	83
Total Site 8-hr L_{EQ}				88.4
With Truck Quieted to 75 dBA				87.0

TABLE 15g. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR COMMERCIAL EXCAVATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	2	1.0	84
Backhoe	85	1	0.16	77
Dozer	87	1	0.4	83
Generator	78	2	1.0	81
Jackhammer	88	1	0.1	78
Loader	79	1	0.4	75
Pump	76	2	1.0	79
Rock Drill	98	1	0.04	84
Shovel	82	1	0.4	78
Truck	88	1	0.4	84
Total Site 8-hr L_{EQ}				91.4
With Truck Quieted to 75 dBA				90.6
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				90.6

TABLE 15h. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR COMMERCIAL FOUNDATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	2	1.0	84
Backhoe	85	1	0.4	77
Concrete mixer	85	1	0.4	81
Concrete pump	82	1	0.08	71
Concrete vibrator	76	1	0.2	69
Jackhammer	88	1	0.04	74
Pile Driver	101	1	0.1	91
Pneumatic tool	85	1	0.04	71
Pump	76	2	1.0	79
Saw	78	3	0.04	69
Total Site 8-hr L_{EQ}				92.6
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				92.0

TABLE 15i. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR COMMERCIAL ERECTION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	2	1.0	84
Concrete mixer	85	1	0.4	81
Concrete pump	82	1	0.4	78
Concrete vibrator	76	1	0.2	69
Crane, derrick	88	1	0.16	80
Crane, mobile	83	2	0.16	78
Jackhammer	88	1	0.04	74
Pneumatic tool	85	2	0.16	80
Pump	76	1	0.4	72
Saw	78	3	1.0	83
Total Site 8-hr L_{EQ}				89.8
With Truck Quieted to 75 dBA (includes concrete mixer)				89.3
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				88.6

TABLE 15j. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR COMMERCIAL FINISHING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	2	0.4	80
Backhoe	85	1	0.04	71
Concrete mixer	85	1	0.16	77
Concrete pump	82	1	0.08	71
Concrete vibrator	76	1	0.04	62
Crane, derrick	88	1	0.04	74
Crane, mobile	83	2	0.04	72
Dozer	87	1	0.16	79
Grader	85	1	0.02	68
Jackhammer	88	1	0.04	74
Loader	79	1	0.16	71
Paver	89	1	0.1	79
Pneumatic tool	85	2	0.04	74
Rock drill	98	1	0.005	75
Saw	78	1	0.1	68
Truck	88	1	0.16	80
Total Site 8-hr L_{EQ}				87.7
With Truck Quieted to 75 dBA (includes concrete mixer)				86.9
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				87.0

TABLE 15k. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR INDUSTRIAL CLEARING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Backhoe	85	1	0.04	71
Dozer	87	1	0.2	80
Generator	78	1	0.4	74
Grader	85	1	0.05	72
Loader	79	1	0.16	71
Scraper	88	1	0.14	80
Truck	88	2	0.16	83
Total Site 8-hr L_{EQ}				86.7
With Truck Quieted to 75 dBA				84.4

TABLE 151. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR INDUSTRIAL EXCAVATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	1.0	81
Backhoe	85	1	0.16	77
Dozer	87	1	0.4	83
Generator	78	1	0.4	74
Jackhammer	88	1	0.1	78
Loader	79	1	0.4	75
Pump	76	1	0.4	72
Rock drill	98	1	0.02	81
Shovel	82	1	0.4	78
Truck	88	2	0.16	83
Total Site 8-hr L_{EQ}				89.5
With Truck Quieted to 75 dBA				88.5
With Compressor Quieted to 71 dBA (76 dBA at 7 m.)				88.9

TABLE 15m. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR INDUSTRIAL FOUNDATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.4	77
Backhoe	85	1	0.4	81
Concrete mixer	85	1	0.4	81
Concrete pump	82	1	0.05	69
Concrete vibrator	86	1	0.2	79
Jackhammer	88	1	0.04	74
Pile Driver	101	1	0.04	87
Pneumatic tool	85	1	0.04	71
Pump	76	2	1.0	79
Saw	78	2	0.04	67
Total Site 8-hr L_{EQ}				90.1
With Truck Quieted to 75 dBA (includes concrete mixer)				89.6
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				89.9

TABLE 15n. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR INDUSTRIAL ERECTION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.4	77
Concrete mixer	85	1	0.16	77
Concrete pump	82	1	0.16	79
Concrete vibrator	76	1	0.1	66
Crane, derrick	88	1	0.04	74
Crane, mobile	83	1	0.08	72
Jackhammer	88	1	0.04	74
Pneumatic tool	85	3	0.1	80
Pump	76	1	0.4	72
Saw	78	2	0.1	71
Total Site 8-hr L_{EQ}				85.8
With Truck Quieted to 75 dBA (includes concrete mixer)				85.3
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				85.3

TABLE 15o. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR INDUSTRIAL FINISHING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.4	77
Backhoe	85	1	0.04	71
Concrete mixer	85	1	0.16	77
Concrete pump	82	1	0.08	71
Concrete vibrator	76	1	0.04	60
Crane, derrick	88	1	0.02	71
Crane, mobile	83	1	0.04	69
Dozer	87	1	0.04	73
Grader	85	1	0.02	68
Jackhammer	88	1	0.04	74
Loader	79	1	0.04	65
Paver	89	1	0.12	80
Pneumatic tool	85	2	0.04	74
Rock Drill	98	1	0.003	73
Roller	74	1	0.1	64
Scraper	88	1	0.08	77
Shovel	82	1	0.06	70
Truck	88	1	0.16	80
Total Site 8-hr L_{EQ}				87.1
With Truck Quieted to 75 dBA (includes concrete mixer)				85.7
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				86.7

TABLE 15p. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR PUBLIC WORKS CLEARING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	1.0	81
Backhoe	85	1	0.04	71
Dozer	87	1	0.3	82
Generator	78	1	1.0	78
Grader	85	1	0.08	74
Jackhammer	88	1	0.5	85
Loader	79	1	0.3	74
Scraper	88	1	0.08	77
Shovel	82	1	0.04	68
Truck	88	2	0.16	83
Total Site 8-hr L_{EQ}				89.9
With Truck Quieted to 75 dBA				89.0
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				89.4

TABLE 15q. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR PUBLIC WORKS EXCAVATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	1.0	81
Backhoe	85	1	0.4	81
Crane, derrick	88	1	0.1	78
Dozer	87	1	0.4	83
Generator	78	1	0.4	74
Jackhammer	88	1	0.5	85
Loader	79	1	0.3	74
Pump	76	2	0.4	75
Rock Drill	98	1	0.02	81
Shovel	82	1	0.4	78
Truck	88	1	0.16	80
Total Site 8-hr L_{EQ}				90.8
With Truck Quieted to 75 dBA				90.4
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				90.4

TABLE 15r. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR PUBLIC WORKS FOUNDATION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.4	77
Concrete mixer	85	2	0.16	80
Crane, derrick	88	1	0.04	74
Dozer	87	1	0.2	80
Generator	78	1	0.4	74
Loader	79	1	0.2	72
Paver	89	1	0.1	79
Pneumatic tool	85	2	0.04	74
Pump	76	2	1.0	79
Roller	74	1	0.01	54
Saw	78	2	0.04	67
Scraper	88	1	0.2	81
Shovel	82	1	0.04	68
Truck	88	2	0.4	87
Total Site 8-hr L_{EQ}				90.6
With Truck Quieted to 75 dBA (includes concrete mixer)				88.0
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				90.4

TABLE 15s. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR PUBLIC WORKS ERECTION

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	1	0.4	77
Concrete mixer	85	2	0.4	84
Crane, derrick	88	1	0.04	74
Crane, mobile	83	1	0.16	75
Generator	78	1	0.4	74
Grader	85	1	0.2	78
Jackhammer	88	1	0.04	74
Paver	89	1	0.5	86
Pneumatic tool	85	1	0.1	75
Pump	76	2	0.4	75
Roller	74	1	0.5	71
Saw	78	1	0.04	74
Scraper	88	1	0.08	77
Truck	88	2	0.2	84
Total Site 8-hr L_{EQ}				90.7
With Truck Quieted to 75 dBA (includes concrete mixer)				88.5
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				88.2

TABLE 15t. EQUIPMENT MIX AND RESULTING NOISE LEVELS FOR PUBLIC WORKS FINISHING

Machine	Noise Level At 50 ft dBA	Number of Machines	Fraction of 8-hr Day in Operation	8-hr L_{EQ} At 50 ft dBA
Compressor	81	2	0.4	80
Backhoe	85	1	0.16	77
Concrete mixer	85	2	0.16	80
Dozer	87	1	0.16	79
Generator	78	1	0.4	74
Grader	85	1	0.08	74
Jackhammer	88	2	0.1	81
Loader	79	1	0.16	71
Paver	89	1	0.5	86
Pneumatic tool	85	1	0.04	71
Roller	74	1	0.5	71
Scraper	88	1	0.08	77
Shovel	82	1	0.04	68
Truck	88	2	0.16	83
Total Site 8-hr L_{EQ}				90.8
With Truck Quieted to 75 dBA (includes concrete mixer)				89.7
With Compressor Quieted to 71 dBA (76 dBA at 7 m)				90.5

5. CORRELATION BETWEEN COMMUNITY NOISE LEVELS AND STANDARD MEASUREMENTS OF COMPRESSOR NOISE LEVELS

5.1 Introduction

Standard measurements of compressor noise levels are useful because they provide a basis for evaluating the impact of compressor noise upon communities. Predictions of the contribution of an air compressor to community noise levels require two types of information: (1) accurate determination of the total sound power developed by the compressor; and (2) descriptions of the propagation of sound waves away from the compressor, including interaction of the waves with solid reflecting and absorbing surfaces.

There are difficulties in obtaining an accurate sound power level. Once a level is obtained, difficulties are encountered in predicting the contribution of compressor noise to community noise. If all the sound waves emanating from a compressor originated at the same point, and if the sound waves spread from that point in the form of a uniformly expanding spherical wavefront, the tasks of finding the sound power level for the compressor and of calculating community noise levels from sound power levels would not be difficult. In fact, all of the sound waves do not arise from the same point. Instead, they emanate from many different regions, which may be characterized by sets of points, lines, or areas. Each point, line, or area may radiate sound more efficiently in particular preferred directions; each generally contributes sound power more efficiently at certain preferred frequencies. The nature of the propagation of sound waves away from these directional, frequency-selective regions depends on the location and geometry of the contributing region and frequency.

If the propagation of sound away from compressors to points more than several hundred feet into the community is of concern, then meteorological factors, e.g., wind, temperature, humidity, and precipitation, may be significant. In addition, obstacles and variations in ground cover may be important. For shorter distances, the propagation may be complicated by the directivity of the source, and by interference phenomena between the sound waves radiated directly from a source and those reflected from nearby surfaces, especially the ground (Francois and Fleury, 1971), (Oncley, 1972), (Bettis and Sexton, 1973).

5.2 The Role of Ground Reflections in Relating Standard Measurements to Community Noise

The CAGI/PNEUROP, ANSI, and ISO measurement procedures for portable air compressors require that noise measurements be performed on an open site above a hard reflecting plane. They require five measurements 1 m away from the machine surfaces and 1.5 m above the ground, and they require five measurements 7 m away from the machine surfaces and 1.2 m (1.5 for ISO-2151-1972) above the ground. The procedures recognize the possible role of constructive and destructive interference between direct sound waves and reflected sound waves at the measurement positions. In particular, large errors may occur when strong discrete frequency components are present. For that reason, techniques require that the measurements shall be made while vertically moving the microphone approximately ±0.3 m from each measurement location, at a minimum rate of 1 cps.

Figure 11 shows the 1/3-octave band corrections to be made to data measured from a point source above a reflecting plane for

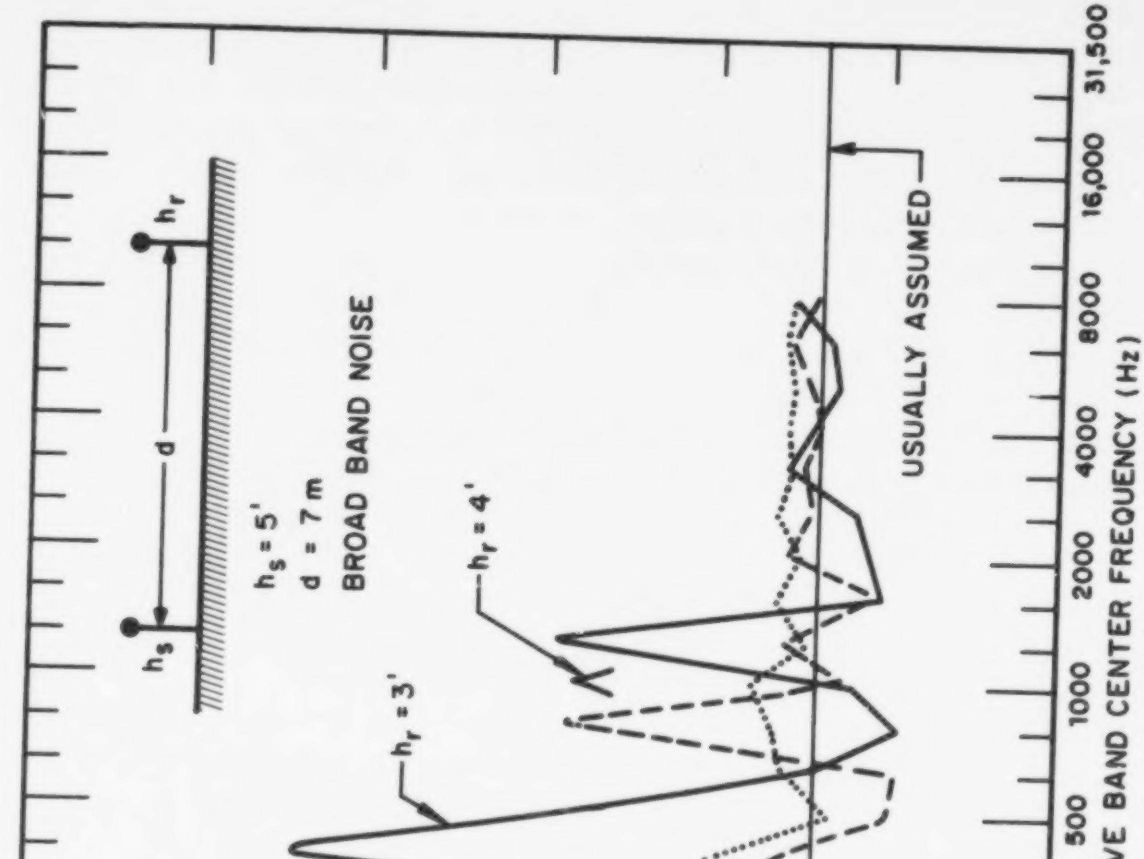


FIG. 11. EFFECT OF CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE BETWEEN DIRECT SOUND WAVES AND WAVES REFLECTED FROM A HARD, NONABSORPTIVE SURFACE.

a typical configuration. The calculations were carried out using Oncley's procedure (1972). His paper showed that results similar to those in Fig. 11 for 1/3-octave band levels can be expected for levels measured in octave bands (with dominant tonals present) and for discrete frequencies. The practical significance of the corrections in Fig. 11 depends on the shape of the measured spectrum. The results in Fig. 11 might be different for the same geometry if the reflecting surface absorbs part of the energy incident upon it. Of course, real sources of compressor noise will not be concentrated at a single point, as assumed in Fig. 11; however, the figure does provide an example of the effect of ground reflections.

Francois and Fleury (1971) examined the suitability of the ISO measurement standard for characterizing the noise radiated by air compressors, in particular for determining the sound power levels. Measurements made in conformance with the standard showed that sound power levels at 7 m cannot be calculated easily from the measured power levels at 1 m. They did not find this surprising in view of the role of ground reflections and nearfield effects at 1 m. Beranek (1971) also warned that reflections can cause error in sound power determinations. In addition to the reflection effect from a perfectly flat ground, Bettis and Sexton (1973) reported that "variations of a few inches in surface flatness may cause significant differences in overall levels and spectral content."

The measurements and calculations described in this report show that ground reflections do not modify the measured sound levels at the standard 7-m measurement position as much as Fig. 11

leads one to expect. For example, Fig. 12 shows A-weighted compressor noise measured 7 m away from a compressor at heights above the ground of 0.6, 1.2, and 1.8 m. While there are sound level variations in some 1/3 octave bands of up to 7 dBA from one height to another, the variation in the overall sound level is ±1 dBA from the central position.

The calculations which led to Fig. 11 were based on the assumption that all of the sound originates at a single point 1.2 m above the ground. The large variations created by the reflected signal can be significantly reduced when the source is not concentrated at a point, but distributed over some finite spatial extent. However, when measuring noise from some noise contributors, such as exhaust pipe outlets, which may radiate from essentially one point at essentially one discrete frequency, the results can be expected to be subject to the large errors indicated in Fig. 11.

The effects of ground reflections on the measured sound levels at the 7-m standard measurement positions appear to be largely "averaged out" by the spatial distribution of the individual noise-making components of a compressor (see Fig. 12).

5.3 The Role of Construction-Site Configuration in Relating Standard Measurements to Community Noise

Construction sites must be examined to determine the extent to which the propagation of compressor sound can deviate from that in free space. The six configurations in Fig. 13 comprise those typical at construction sites. The half space shown in this figure represents the area surrounding a compressor during testing

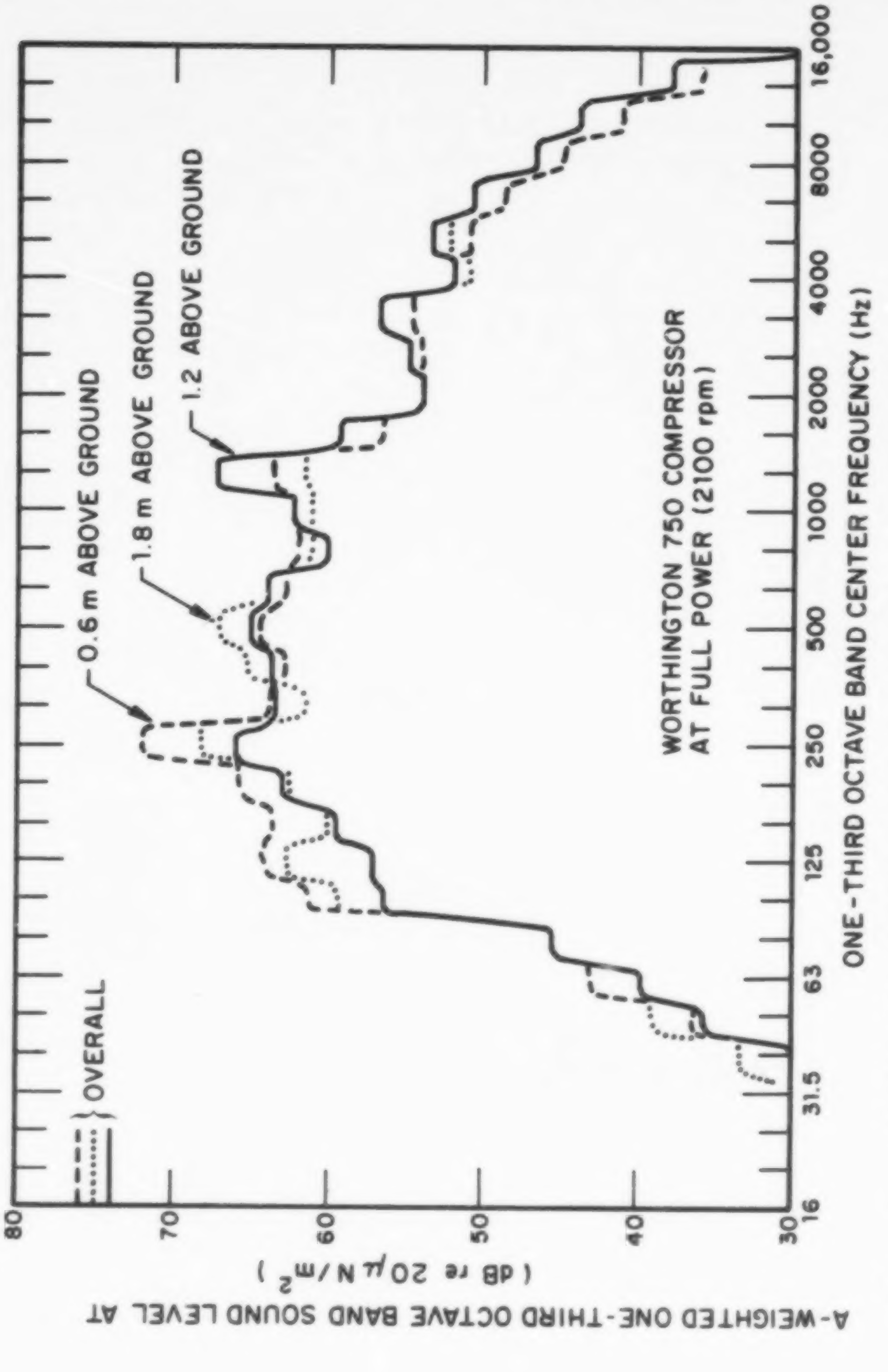
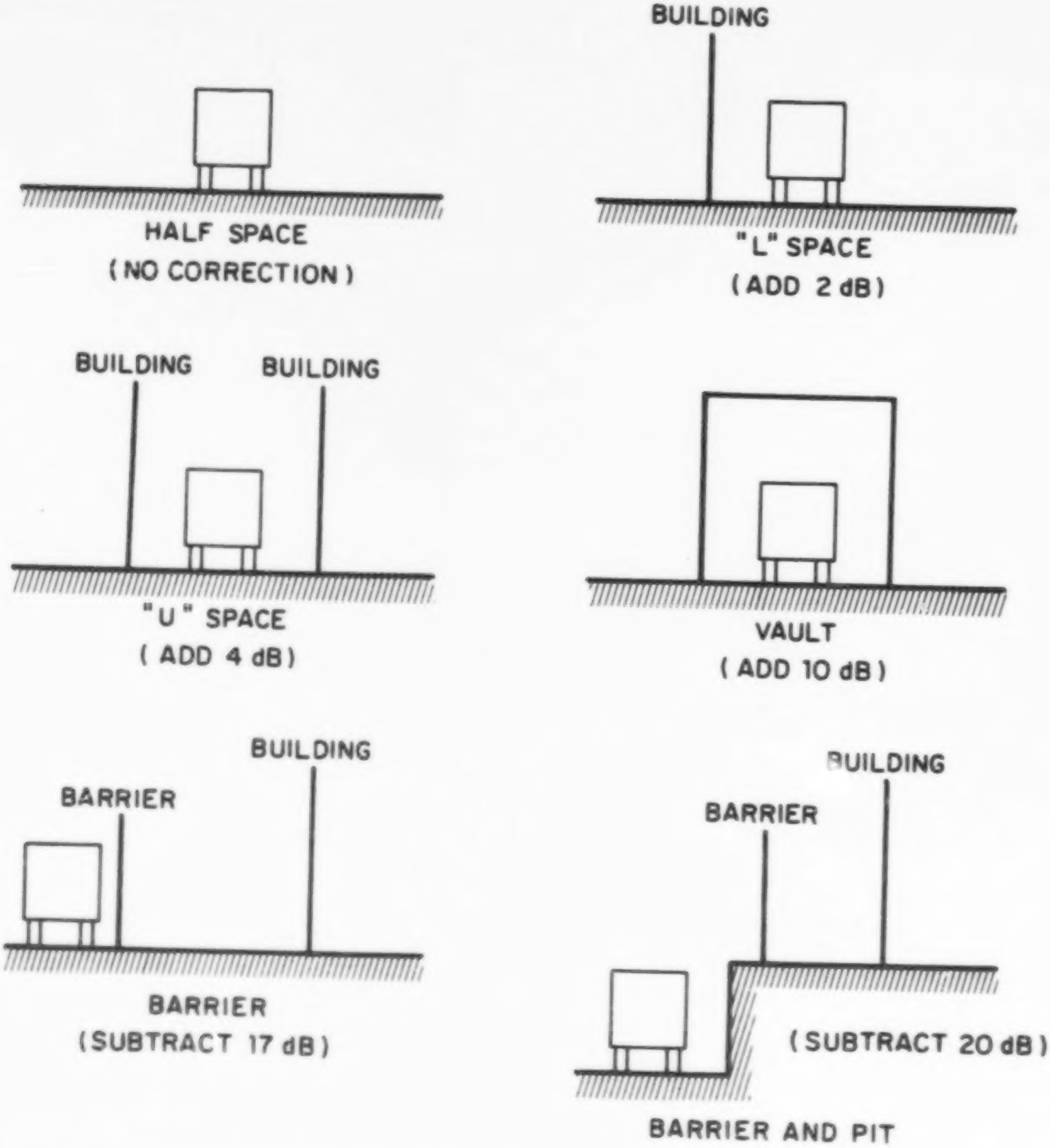


FIG. 12. EFFECT OF MICROPHONE HEIGHT ON A-WEIGHTED SOUND AT 7 M.

per ISO-2151-1972 or when used during construction in a residential or light industrial area. Sound propagating in a half space is subject to the interference effects discussed previously. When a compressor in a residential or light industrial area is next to a building, the buildings usually are far enough apart to be described by the "L" space in Fig. 13. Anderson *et al.* (1973) reported that sound propagates in an "L" cross section as it does in free space. The sound level at a point in an "L" space is expected to be on the order of 3-dBA higher than the sound level measured at the same point in a free field over a reflecting plane, because the sound energy is concentrated in a smaller volume in an "L" space than in a half space. Francois and Fleury (1971) measured a corresponding 2-dBA increase in compressor noise in an "L" space.

The "U" space in Fig. 13 is representative of city "canyons" formed by a street or alley and the vertical walls of nearby buildings. Appendix A discusses the propagation of sound in city canyons in more detail. It also includes the results of calculations carried out using an extension of the theory of Weiner *et al.* (1965). This theory shows that a nondirectional source produces sound levels in a typical city canyon which are 6-dBA higher 100 ft from the source than the levels present in a half space. Francois and Fleury (1971) measured a corresponding 4-dBA increase for a "U" space of different dimensions from the "U" space analyzed in Appendix A.

There is some concern that the sound levels experienced in the upper stories of city buildings might be unusually high if the observers are located above a compressor with pronounced


BUILDING
BUILDING
BUILDING
BUILDING
BARRIER
BUILDING
BARRIER

HALF SPACE (NO CORRECTION)

"L" SPACE (ADD 2 dB)

"U" SPACE (ADD 4 dB)

VAULT (ADD 10 dB)

BARRIER (SUBTRACT 17 dB)

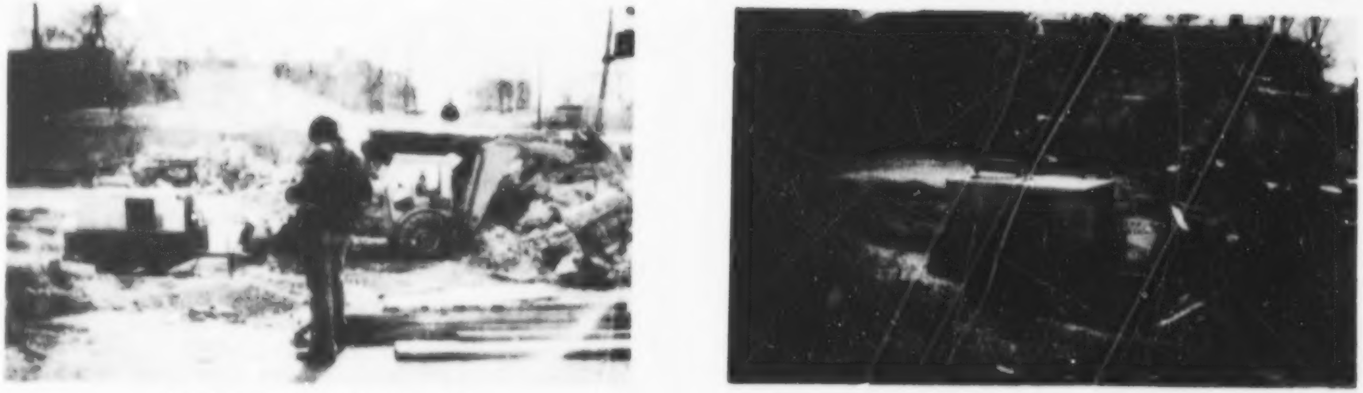
BARRIER AND PIT (SUBTRACT 20 dB)

FIG. 13. CONFIGURATIONS OF LOCATIONS OF COMPRESSORS AT CONSTRUCTION SITES (CORRECTIONS ARE FOR SOUND LEVELS AT 7 M FROM THE MACHINE SURFACE WHEN COMPARED TO THE HALF-SPACE LEVELS).

vertical directivity, particularly if the compressor sound is confined within a city canyon. Appendix A shows that an air compressor that radiates sound four times as efficiently (in terms of intensity) in the vertical direction as in the horizontal direction will expose people in city buildings to less than 4-dBA higher sound levels than an air compressor that uniformly radiates an amount of sound energy equal to that radiated by the directive source.

A compressor operated under a bridge or overpass can be described in terms of the vault space in Fig. 13. The sound levels generated in such a space can be more than 10-dBA higher than the sound levels generated in a half space (Francois and Fleury, 1971).

The barrier and pit configurations depicted in Fig. 13 are typical of construction sites in cities. Usually, the construction of a building in a city center begins with the erection of a tall board fence. During the initial ground breaking, compressors operate at ground level behind the fence. As excavation proceeds, compressors operate within the pit dug for the basement floors. Figure 14 includes a photograph of an air compressor located in a shallow pit behind a relatively low barrier at a construction site in a commercial zone of Cambridge, Massachusetts. Calculations presented in Appendix B show that pits and barriers can reduce the noise levels experienced by outdoor ground-level observers by as much as 20-dBA below the levels experienced in an unobstructed half space. The benefits to upper-story observers in buildings across the street depend on the construction stage and on the observer's elevation. If there are vertical reflecting



CONSTRUCTION SITE

AIR COMPRESSOR

WHEEL LOADER

BACKHOE WITH PAVING BREAKER TRUCK IN BACKGROUND

FIG. 14. AN AIR COMPRESSOR LOCATED IN A SHALLOW PIT BEHIND A RELATIVELY LOW BARRIER AT A CONSTRUCTION SITE IN CAMBRIDGE, MASS.

surfaces in addition to those shown in the barrier configurations in Fig. 13, then the effectiveness of a barrier might be reduced.

Predictions of compressor noise for the six configurations considered typical construction site scenarios provide a basis for comparing test data with community noise. The noise levels inside buildings and automobiles due to air compressors are determined by the noise reduction provided by these structures. Noise reduction by structures is frequency dependent; therefore, it varies with the shape of the sound spectrum generated by compressors. In addition, the shape of the sound spectrum that is propagated away from a compressor may not be the same as the shape of the spectrum near the compressor, because some mechanisms involved in the sound propagation, such as reduction due to barriers, are more effective at some frequencies. In short, it is difficult to generalize a relation between test noise levels and noise levels inside automobiles and buildings.

5.4 Upward-Directed Measured Air Compressor Noise

Some concern has developed that an emission standard patterned along the lines of the CAGI/PNEUROP technique might be insufficient in that no overhead measurement is required. In urban environments, upward directed noise from air compressors can be as important as noise emanating in a horizontal direction (see Appendix A).

Therefore, noise measurements taken by BBN included an overhead location, 7-m above the top surface of the compressors. These measurements were made by attaching a microphone and preamplifier to a 10-m long pole constructed of interlocking aluminum tubes. A slight curve provided by the flexibility of the pole allows the microphone to be positioned over the approximate center of the compressor. This technique works quite well; once the pole is assembled, approximately 10 extra minutes are required for this measurement.

Table 16 lists the measured CAGI/PNEUROP average and overhead noise levels for the 26 compressors tested. The last column in this table is the difference in these two levels, and Fig. 15 shows a histogram of these differences.

For 4 of 26 compressors, the overhead noise level is greater than noise emanating horizontally. All other models show the overhead direction to be quieter than, or equal to, horizontal noise. The mean difference in Fig. 15 shows the upward-directed noise to be 0.6-dBA less than the CAGI/PNEUROP figure. The spread in the data, however, creates a standard deviation of 2 dBA.

Of the four compressors that are significantly noisier overhead, two results are for the same model (doors open and closed) with a relatively inefficient exhaust muffler. The other two results are for silenced units similar to companion products with overhead sound levels significantly less than the sideline average. Consequently, if we momentarily ignore these results as atypical or possible measurement error, the statistics of the remaining 20 are computed. The following values result:

Mean: -1.5 dBA

σ = 1.1 dBA .

Thus, for this group of compressors, the overhead noise level is about 1.5-dBA less than in other directions.

TABLE 16. COMPARISON BETWEEN CAGI/PNEUROP AND OVERHEAD NOISE LEVELS (dBA).

No.	Manufacturer	Model	(A) BBN CAGI/PNEU.	(B) Overhead	B-A
1	Atlas Copco	ST-48	84	83	-1
2	Atlas Copco	ST-95	80.5	79.5	-1
3	Atlas Copco	VSS-170 Dd	71	68	-3
4	Atlas Copco	VT-85 Dd	82.5	79	-3.5
5	Atlas Copco	VS-85 Dd	75.5	76	0.5
6	Atlas Copco	VSS-125 Dd	70	72.5	2.5
7	Atlas Copco	STS-35 Dd	73	77	4
8	Atlas Copco	VSS-170 Dd	71	68.5	-2.5
9	Worthington	160 G/2 QT	75	72	-3
10	Worthington	750-QTEX	75	73.5	-1.5
11	Ingersoll-Rand	DXL 1200	94.5		
12	Ingersoll-Rand	DXL 1200 doors open	96.5		
13	Ingersoll-Rand	DXL 900S	77.5	75	-2.5
14	Ingersoll-Rand	DXL 900S	75.5	74.5	-1
	Ingersoll-Rand	DXL CU1050	91	89	-2
16	Ingersoll-Rand	DXL 900S	76	73.5	-2.5
17	Ingersoll-Rand	DXL 900S	75.5	74	-1.5
18	Ingersoll-Rand	DXL 900	90.5	89	-1.5
19	Ingersoll-Rand	DXL 750	88	88	0
20	Gardner-Denver	SPWDA/2	74	73	-1
21	Gardner-Denver	SPQDA/2	78.5	78	-0.5
22	Gardner-Denver	SPHGC	77.5	75	-2.5
23	Jaeger	A	88.5	88	-0.5
24	Jaeger	A doors open	89	89.5	0.5
25	Jaeger	E	81.5	84	2.5
26	Jaeger	E doors open	82	85	3

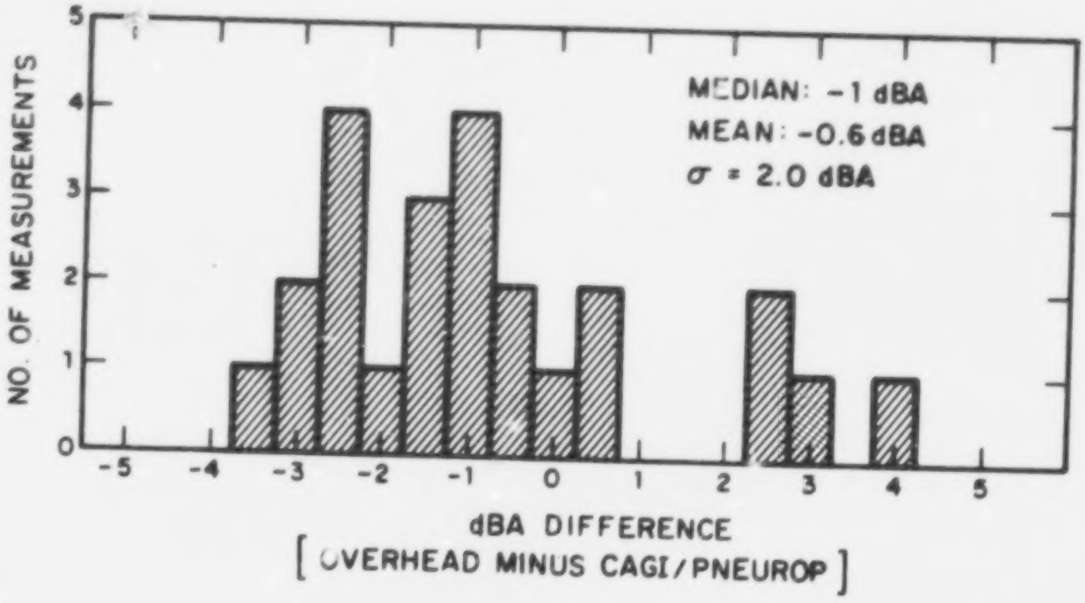


FIG. 15. COMPARISON BETWEEN OVERHEAD LEVEL AND CAGI/PNEUROP LEVEL

5.5 Conclusions

Measurements and calculations like those described in this and previous sections can lead to a well-defined method for determining sound power levels of useful accuracy for portable air compressors. Once sound power levels of acceptable accuracy are determined, a common basis is provided for analysis of the complex propagation modes of compressor noise into communities, including considerations of the effects of ground reflections, ground attenuation, obstacles, and meteorological factors.

A suitable test would require measurement of the sound levels at 7-m distances from the machine surface in the cardinal directions (positions 7, 8, 9, and 10). During the measurement, the microphone would be slowly swept through the selected height vertically over a 1-m distance (± 0.5 m). The reported level for each position would be the maximum level read during the sweep. Noise level limits would be based on the average sound level of the four readings (averaged of antilogs if deviation is greater than 5 dB). The physical dimensions of the compressor would also be reported. This test is based on compatibility with present sound test procedures and simplicity of measurements. The addition of an overhead measurement will not increase the accuracy of the measurement for most compressors, but will will provide added assurance that all compressors are designed for equal noise radiation with no significant overhead directivity.

APPENDIX A: COMPRESSORS IN CITY CANYONS

Part of the description of community exposure to air compressor noise consists of predicting the noise heard by people on the streets or in nearby buildings. There is some concern that the sound levels experienced by upper-story observers might be unusually high if observers are located above a compressor with pronounced vertical directivity, particularly if the compressor sound reverberates within the city "canyon." Figure 16 shows the configuration of interest. The compressor will not necessarily be located in the middle of the street.

Weiner *et al.* (1965) describes the reverberation effect from building walls on sound transmitted from a directive source near the ground in the middle of a street to an observer at the same location. Their analytical expressions were extended for this analysis in order to account for observers at windows in multistory buildings in the line of sight of the compressor. Examination of these resulting equations shows that the predicted sound levels are insensitive to the position of a source across the width of a street, as long as the distance from the source to the observer is greater than one street width. The analysis, which applies to the configuration shown in Fig. 16, is based on the following assumptions:

1. The effect of multiple sound reflections at the side walls can be approximated by replacing the walls with an infinite set of image sources.

2. The influence of a perfectly reflecting pavement can be approximated by doubling the effective source strength, assuming that the receiver is beyond the region of ground-plane image interference.

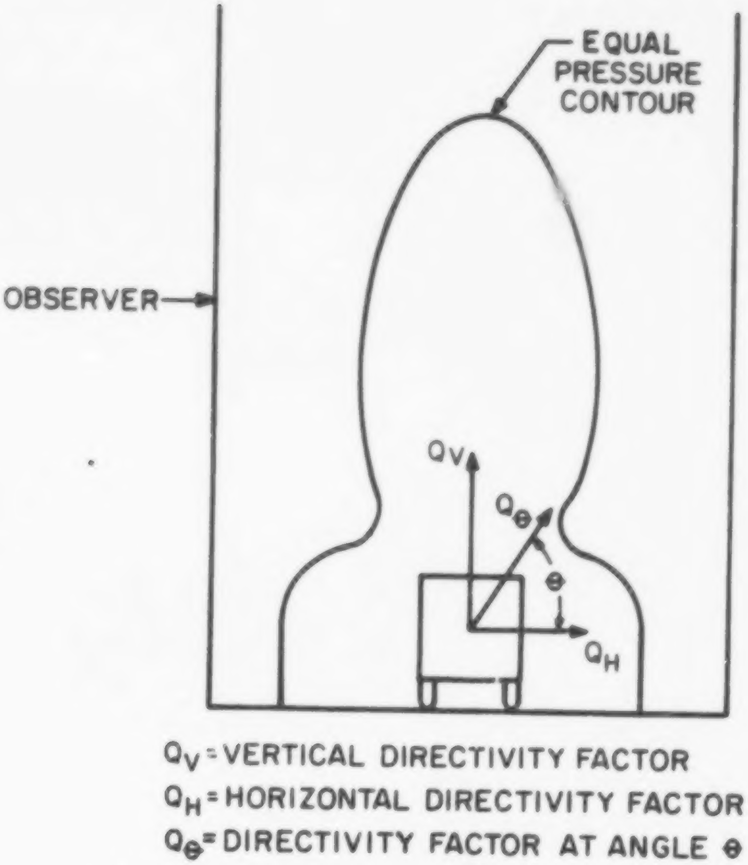

EQUAL PRESSURE CONTOUR
OBSERVER
Q_V
Q_θ
θ
Q_H
Q_V = VERTICAL DIRECTIVITY FACTOR
Q_H = HORIZONTAL DIRECTIVITY FACTOR
Q_θ = DIRECTIVITY FACTOR AT ANGLE θ

FIG. 16. AN AIR COMPRESSOR IN A CITY CANYON.

3. The open top of the slot shown in Fig. 16 can be accounted for by including upward scattering of energy (out of the slot) in an effective wall absorption coefficient.

4. The reverberant sound field can be calculated with useful accuracy without including directivity in image sources.

Figure 17 shows the sound levels generated by a compressor located on a street 30-m wide (see Fig. 16). The levels in Fig. 17 are relative to 0 dBA at 7 m from a nondirectional compressor. A value of 0.3 is used for the average absorption coefficient of the external reflecting surfaces of city buildings. That value was measured by Wiener *et al.* (1965).

In the profiles in Fig. 17, the sound levels produced in a reverberant city canyon by a nondirectional source are compared with those from a source with pronounced vertical directivity. The figure applies to a directive source which produces a sound level at a point along the vertical axis that is 6-dBA higher than the sound level generated at the same distance along the horizontal axis (a factor of 4 in energy). Figure 17 shows the results of calculations which indicate that the directional compressor produces sound levels at elevated points along building walls that are about 4- to 5-dBA higher than the noise levels produced at the same points by a nondirectional air compressor which generates the same total acoustic energy. The sudden change in the general profile configuration beyond 72 m from the source reflects the dominance of reverberant over directly radiated sound energy beyond that point.

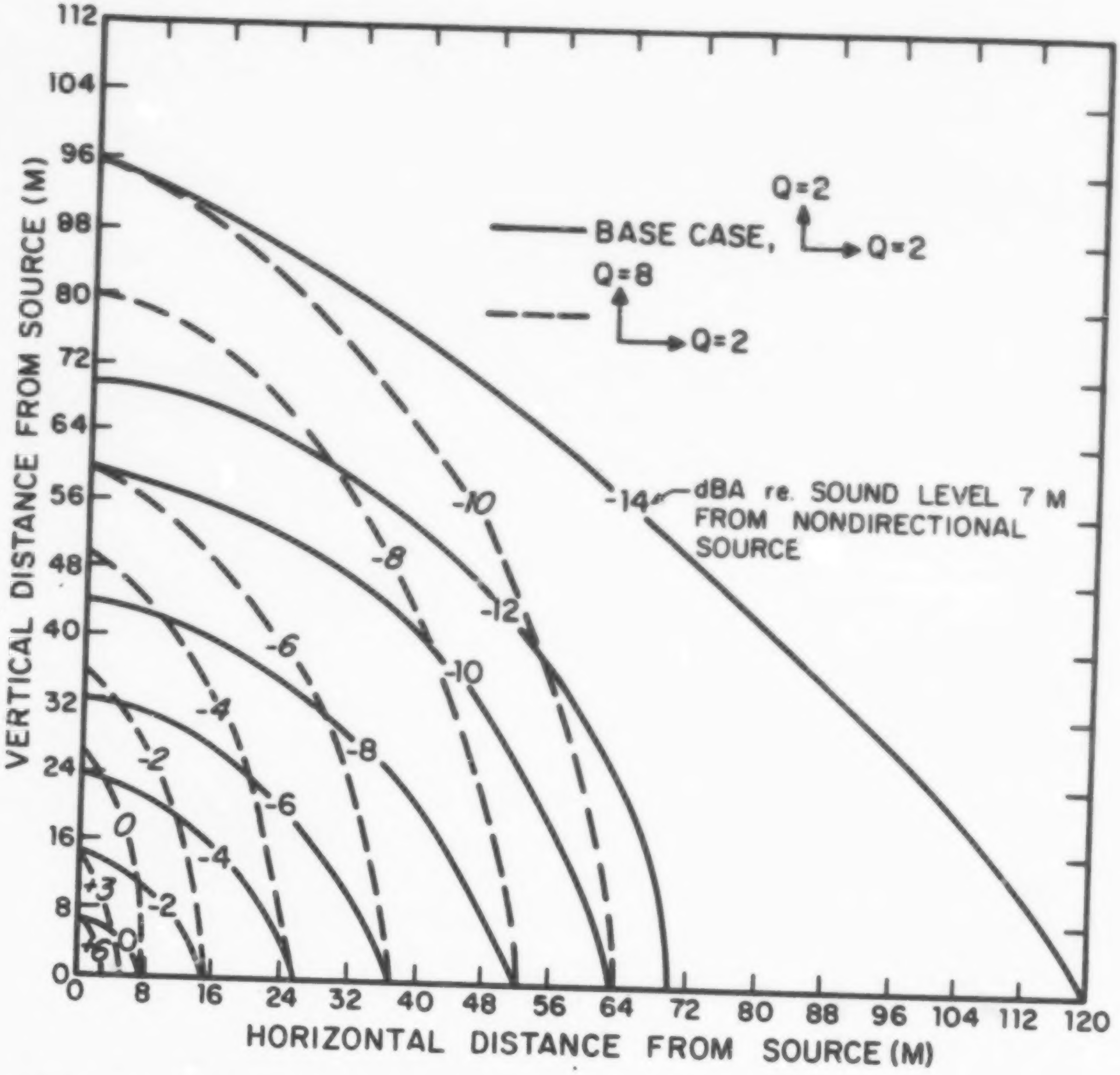


FIG. 17. EFFECT OF SOURCE DIRECTIVITY AND REVERBERANT SOUND FIELD IN CITY CANYONS.

The definition of the directivity factor, Q_θ, (Beranek, 1971) used in the analysis that led to Fig. 17 assures that the comparison is on an equal energy basis. The sound level, SPL_θ, at angle θ and a distance r meters from a compressor is related to the sound power level, PWL, of the compressor in a half space by

$$PWL = SPL_\theta - 10 \log Q_\theta + 20 \log r + 8 \quad . \tag{9}$$

Therefore, if the directivity factor and the sound level at any given point are held constant in exchanging sources, the sound power level of the two sources must be constant. That process might lead to an unusual iso-pressure profile between the horizontal and vertical axes, but the quality of the analysis would not be improved significantly by changing Q in the horizontal direction to accommodate a different pressure profile. The profiles in Fig. 17 are mainly of interest for examining the points along the vertical axis. The "end-points" on the two axes were connected for "bookkeeping" purposes.

The analysis described above is based on the assumption that it is not necessary to include the directivity of the source in the image sources used to represent reverberation. Wiener *et al.* (1965) discussed the direction of the errors that can result from that assumption. They reported that when a receiver is outside of the radiation cone from the most important images, the calculated level of the reverberant sound field will be high. That means that the sound levels produced at points above a directional air compressor in a city canyon will differ from the sound levels produced at the same points by a nondirectional air compressor by less than the 4 dBA (see Fig. 17). In this case, the directivity of the source subtracts from the reverberant sound field in such a way as to cancel partially the directivity effect on the total sound field in the city canyon.

APPENDIX B: COMPRESSORS AT URBAN CONSTRUCTION SITES

The construction of a building in the center of a city usually begins with the erection of a tall board fence. During the initial ground breaking, compressors operate at ground level behind the fence. As excavation proceeds, compressors operate within the pit dug for the basement floors. Figure 18 shows a typical configuration. The barrier alone provides significant reduction of compressor noise heard by ground-level observers either immediately adjacent to the barrier or across the street from the barrier. In addition, the pit provides a slight increase in the noise reduction. The contribution of either the barrier alone, or the barrier-pit combination to the noise reduction decreases as the elevation of the observer increases. Figure 18 shows the limits on the elevation of an observer who will benefit from the barrier-pit combination. If there are vertical reflecting surfaces in addition to those shown in Fig. 18, then the effectiveness of a barrier might be reduced.

The amount of reduction of compressor noise by pits and barriers is calculated by means of the Kurze and Anderson method (1971). Although construction site fences are usually about 6-ft high, a 15-ft acoustically opaque fence was chosen for the calculations in order to provide an upper limit to the practically attainable reduction of compressor noise by barriers.

Figures 19 and 20 show the effect of a barrier and a pit on noise from a typical compressor 2 ft and 100 ft from the construction site boundary (see Fig. 18 also). Anderson *et al.* (1973) reported that sound propagates in an "L" cross section (see Fig. 19) as it does in free space, so the considerations

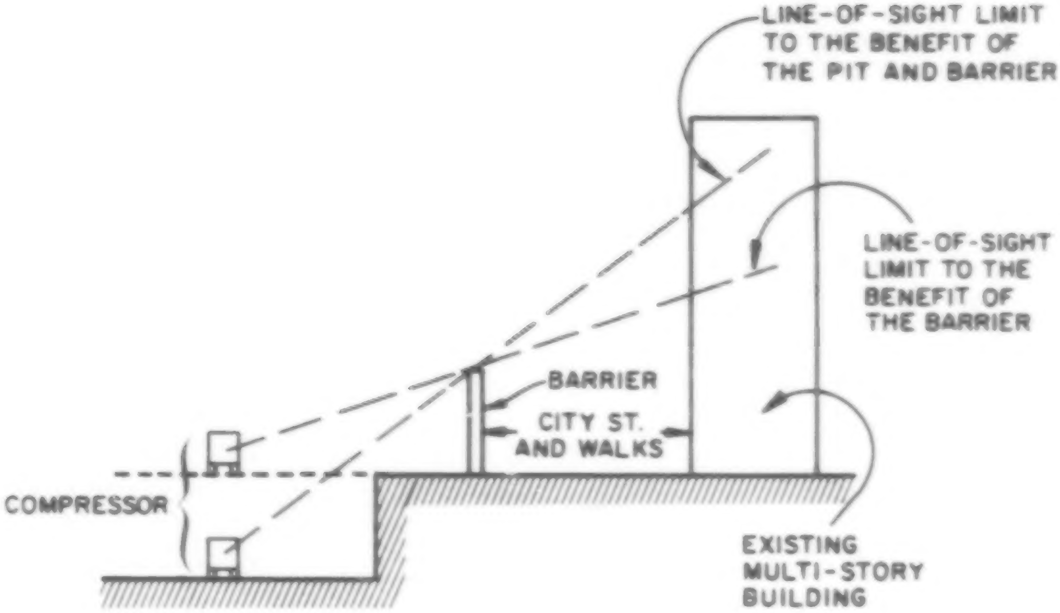

LINE-OF-SIGHT LIMIT TO THE BENEFIT OF THE PIT AND BARRIER
LINE-OF-SIGHT LIMIT TO THE BENEFIT OF THE BARRIER
BARRIER
CITY ST. AND WALKS
COMPRESSOR
EXISTING MULTI-STORY BUILDING

FIG. 18. CONFIGURATION OF THE CONSTRUCTION SITE OF A BUILDING IN THE CENTER OF A CITY.

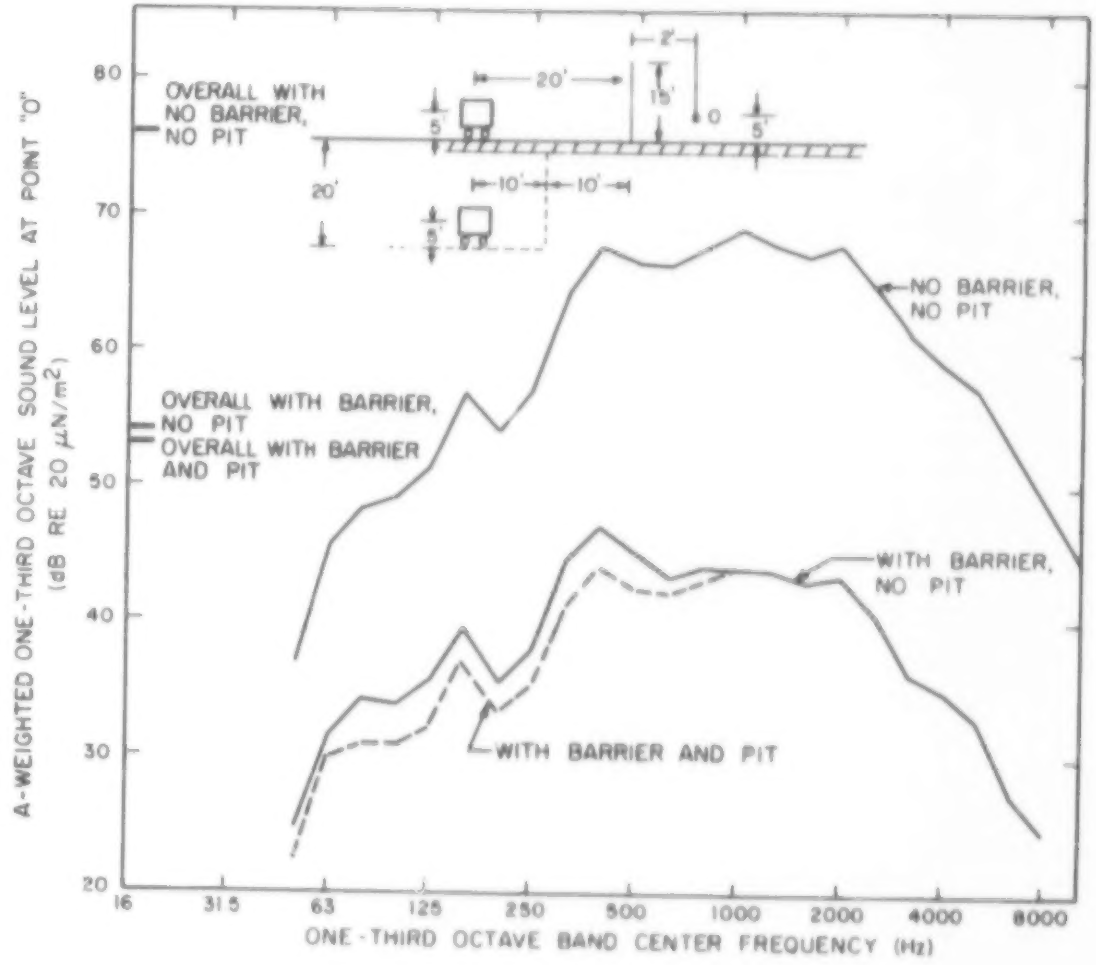


FIG. 19. EFFECT OF A BARRIER AND A PIT ON COMPRESSOR NOISE 5 FT FROM THE GROUND AND 2 FT FROM THE BOUNDARY OF A CONSTRUCTION SITE (76-dBA COMPRESSOR PER ISO-2151-1972).

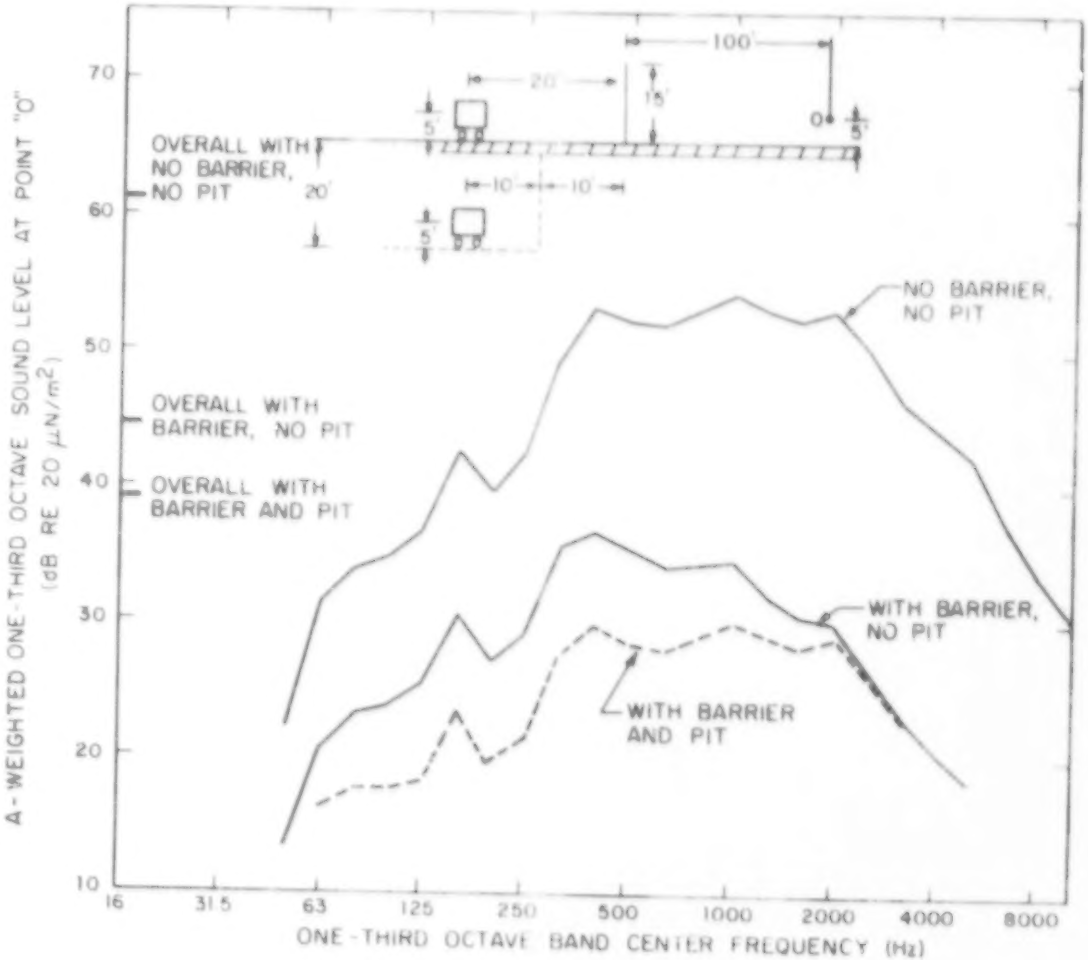


FIG. 20. EFFECT OF A BARRIER AND A PIT ON COMPRESSOR NOISE 5 FT FROM THE GROUND AND 100 FT FROM THE BOUNDARY OF A CONSTRUCTION SITE (76-dBA COMPRESSOR PER ISO-2151-1972).

of reverberant buildup described in Appendix A are not required for this particular configuration. Of course, the configuration deviates from an "L" shape in that there are vertical surfaces several street widths opposite the existing building. However, the equations for Appendix A show that the reverberant field is negligible for such a wide "canyon." Even if the vertical surfaces do not contribute significantly to a reverberant field, they may scatter and reflect sound in such a way as to reduce the effectiveness of pits and barriers.

Figure 21 shows the calculated contribution of barriers and pits to the reduction of compressor noise heard by upper-story observers across the street from a construction site (see Fig. 18). For observers who are far enough above ground to see the compressor, there is no benefit from a barrier or a pit. As the walls of the new building are erected, they provide additional attenuation of the compressor noise in the street and nearby buildings.

Some compressors are characterized by flatter spectra than those in Figs. 19 and 20. The overall noise reduction provided by a barrier is a function of the noise spectrum shape. However, the changes in the barrier effectiveness brought about by variations in spectrum shape are not large for the configuration discussed here.

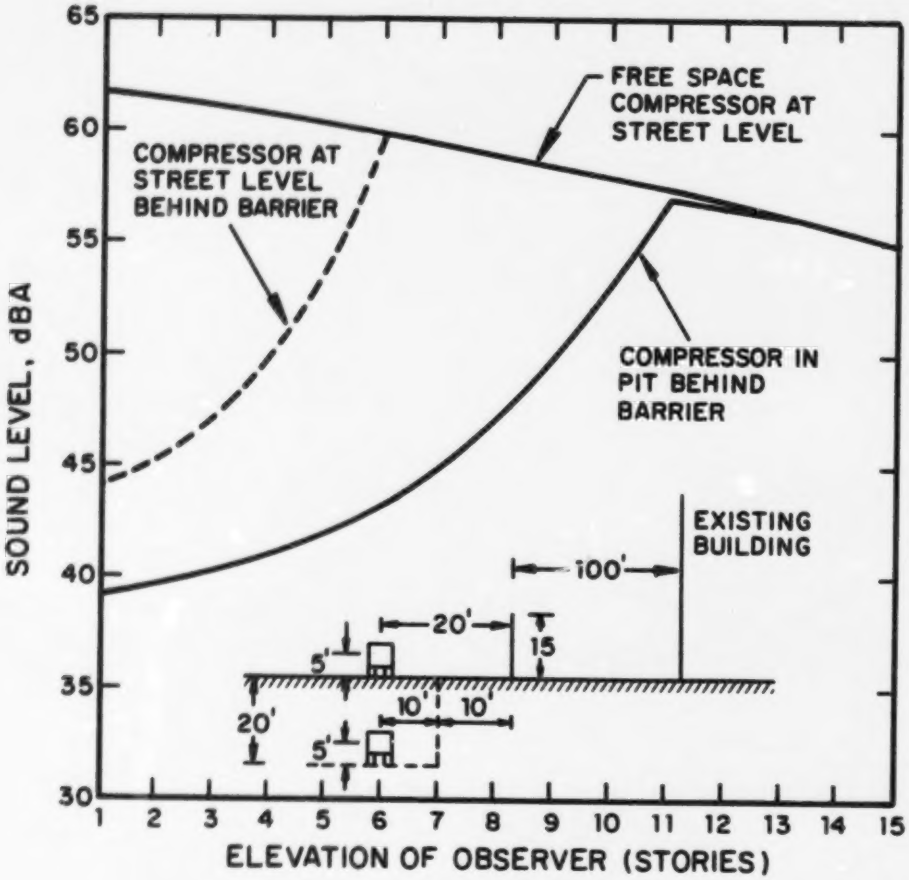


FIG. 21. EFFECT OF A BARRIER AND A PIT ON COMPRESSOR NOISE IN THE UPPER STORIES OF A BUILDING 100 FT FROM THE BOUNDARY OF A CONSTRUCTION SITE (76-dBA COMPRESSOR PER ISO-2151-1972).

APPENDIX C

RESULTS OF AIR COMPRESSOR MEASUREMENTS

MANUFACTURER: ATLAS COPCO

COMPRESSOR

Type: Reciprocal
Model: ST-48
Serial: 51232751
Capacity: 160 cfm, 100 psi

ENGINE

Make: Deutz F4L 912
Horsepower: 50
Rated Speed: 1750 rpm

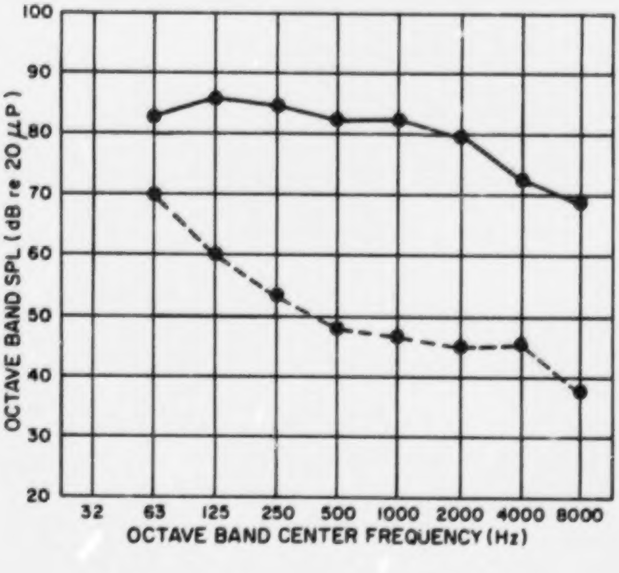
Test Date: 1/25/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 1-2 mph
Temperature: 45° F

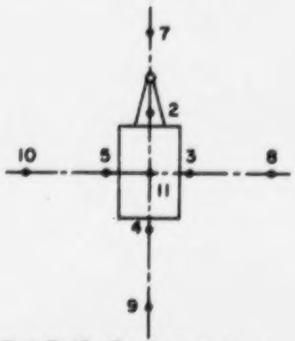
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	81	87	88	81
	Linear	94.5	97	97.5	97
Full Power	dBA	95.5	98	99	94
	Linear	104	104	103	102.5

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	72	75	74	82	77	
	Linear	83	87	86	87	88	
Full Power	dBA	84	83	86	82	83	55
	Linear	92	93	91	92.5	92	71
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	90	89	82	89	89	70
	125	80	87	85	86.5	85	60
	250	79	80	84	82	83	53
	500	82	78	82	78	78	48
	1000	81	79	82	78	75	47
	2000	75	76	79	75	75	45
	4000	69	69	72	63	68	45
	8000	66	67	69	63	64	38



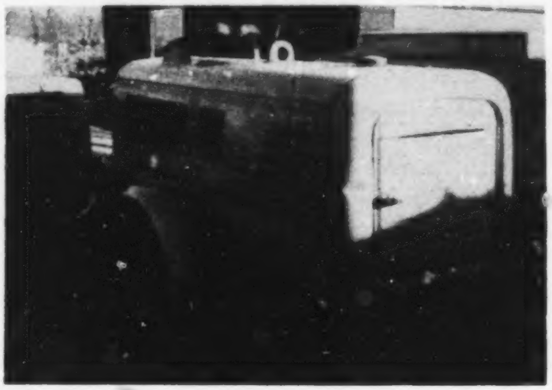


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO



COMPRESSOR

Type: Reciprocal
Model: ST-95
Serial: 51-274977
Capacity: 330 cfm, 105 psi

ENGINE

Make: Deutz BF 6L 913
Horsepower: 93
Rated Speed: 1750 rpm

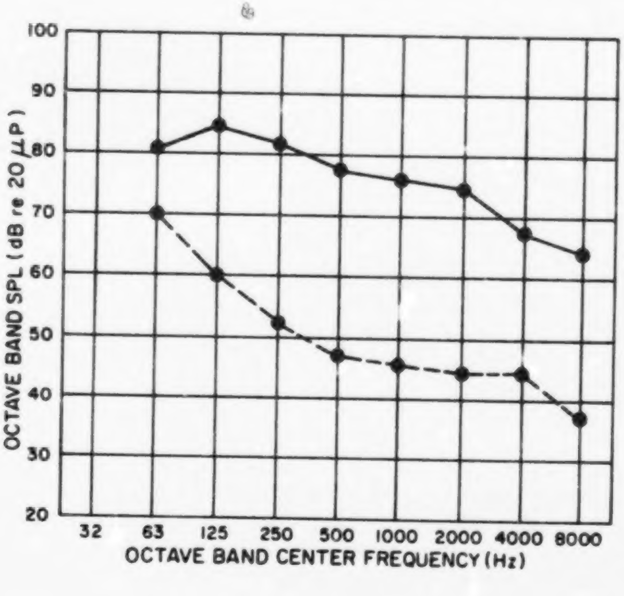
Test Date: 1/25/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 2-3 mph
Temperature: 40° F

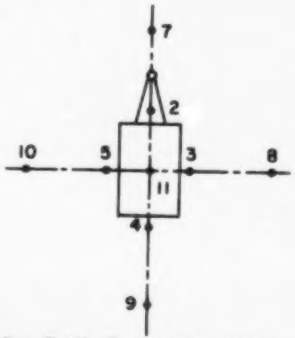
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	85	93.5	94.5	87
	Linear	91.5	96	91.2	92.3
Full Power	dBA	90	95	92.5	90
	Linear	97.5	101.5	98.5	98.5

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	76	76	80	77	77	
	Linear	83.5	88	86	85	85	
Full Power	dBA	79	82	81.5	79	79.5	55
	Linear	90	91	89	89	88.5	71
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	85	81	81	86	83	70
	125	83.5	85	84	81	85	60
	250	80	82	84	81	80	53
	500	77	78	79	76.5	77	48
	1000	74	77	78	74	76	47
	2000	70	75	73	72	73	45
	4000	64	68	66	65	68	45
	8000	58	64	65	58	62	38



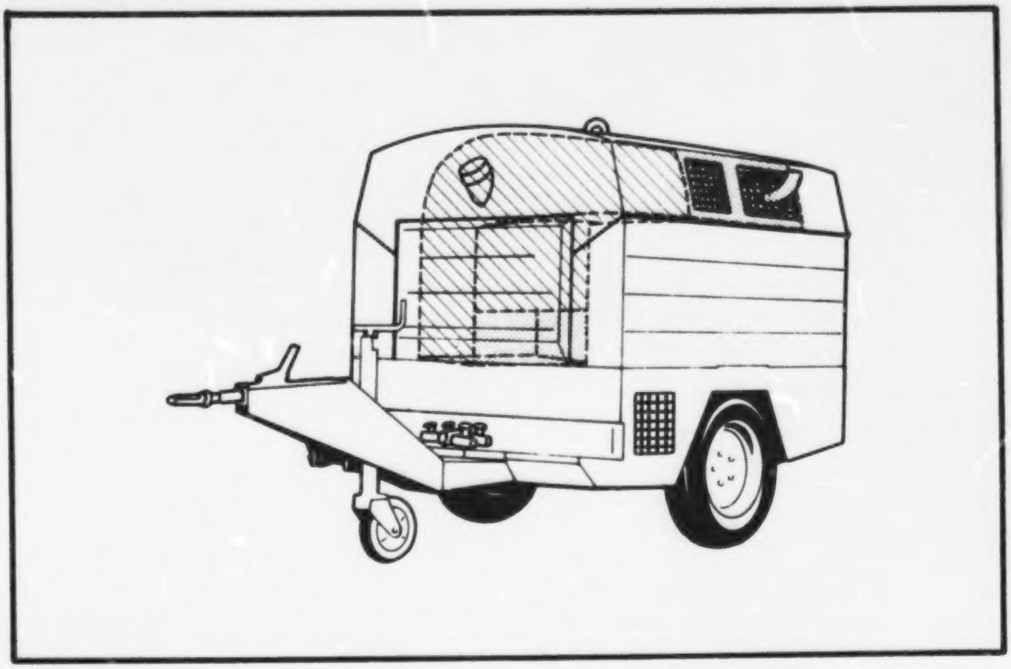


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO



COMPRESSOR		**ENGINE**	
Type:	Reciprocal	**Make:**	Deutz F4L 912
Model:	VSS 170 Dd (Silenced)	**Horsepower:**	50
Serial:	51-235072	**Rated Speed:**	1750 rpm
Capacity:	170 cfm, 85 psi		

Test Date:

Test Type: Mod. CAGI/PNEUROP

Surface: Asphalt

Wind: 2-3 mph

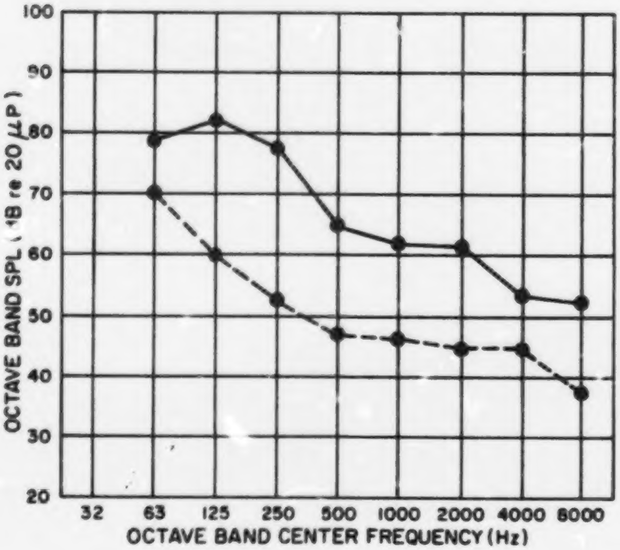
Temperature: 36° F

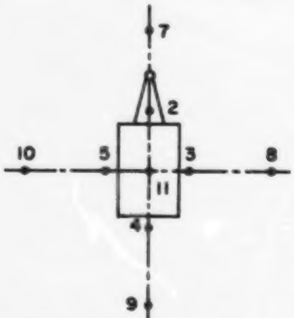
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	71	69	70	71
	Linear	97	93	95	98
Full Power	dBA	76	73	77	76
	Linear	101	101	100	103

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	63	63	61	62	63	
	Linear	90	90	86	88	86	
Full Power	dBA	70.5	70	70	72	68	55
	Linear	92.5	92	93	90	90	70.5
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	90	88	85.5	79	80	70
	125	82	81	76.5	82	76	60
	250	70	71	71	78	69	53
	500	67	64	63	65	67	48
	1000	61	60	61	62	63	47
	2000	60	60	61	61	61	45
	4000	55	57	53	53	57	45
	8000	52	65	51	52	53	38



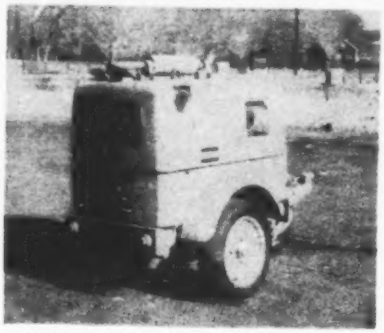


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO



COMPRESSOR

Type: Reciprocal
Model: VT85 Dd
Serial: ARP 203149
Capacity: 85 cfm

ENGINE

Make: Deutz F4L 912
Horsepower: 50
Rated Speed: 1750 rpm

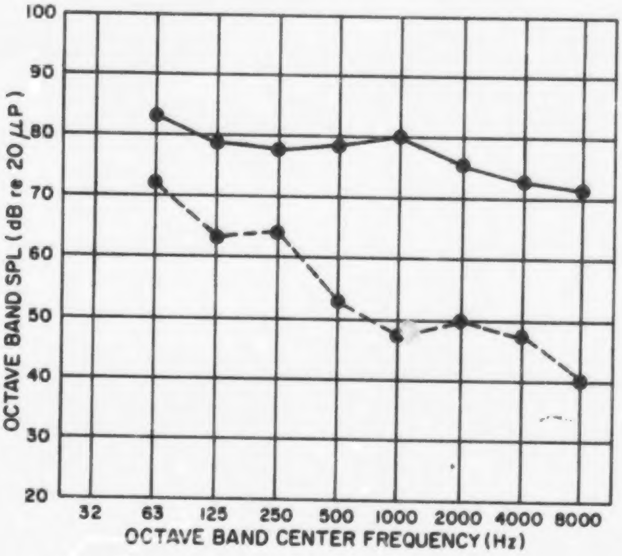
Test Date:
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 10 mph
Temperature: 25° F

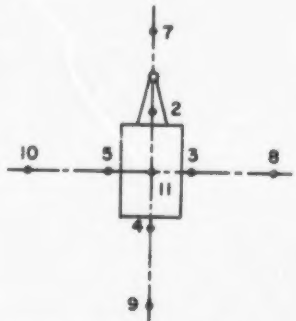
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	92.5	87	90.5	92.5
	Linear	103	100	100	100
Full Power	dBA	95	92.5	95.5	96
	Linear	103	101.5	100	101.5

SEVEN-METER LEVELS

Level / Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	75	74	73.5	73	75.5	
	Linear	92.5	91	95	96	91	
Full Power	dBA	81.5	80	83.5	83	79	65
	Linear	94	91	92.5	93	90.5	83
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	84.5	85	83	84	78	72
	125	79.5	81.5	79	81	78.5	63
	250	76.5	79.5	78.5	80	78.5	64
	500	76	74	78.5	77	75	53
	1000	75	75	80	76.5	73.5	48
	2000	73.5	75	75	76.5	72.5	50
	4000	71	71	72	72.5	69	48
	8000	69.5	69	71	71	67	40





Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO

SILENSAIR
SILENSAIR

COMPRESSOR

Type: Reciprocal
Model: VS85 Dd (Silenced)
Serial: ARP 203903
Capacity: 85 cfm

ENGINE

Make: Deutz F2L 912
Horsepower: 25
Rated Speed: 1800 rpm

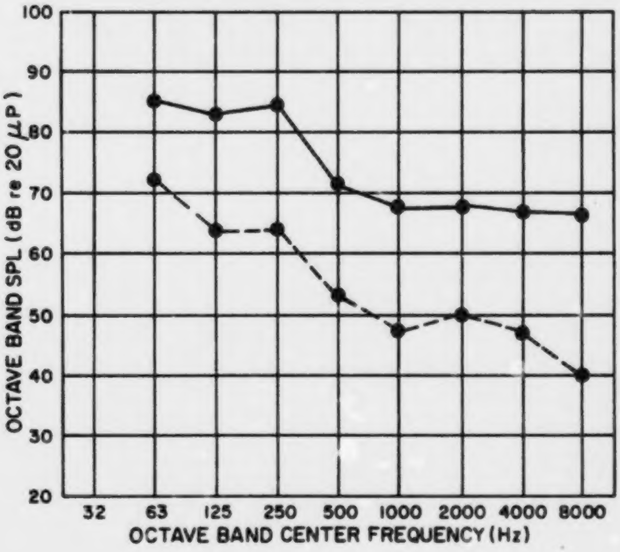
Test Date:
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 10 mph
Temperature: 25° F

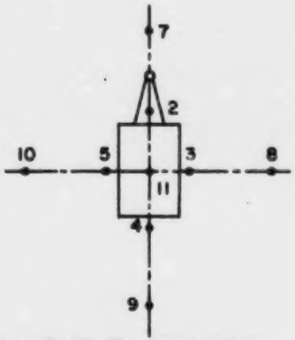
ONE-METER LEVELS

Level	Pos.	2	3	4	5
Idle	dBA	83	81	83.5	84
	Linear	101	100	100	100
Full Power	dBA	88.5	87.5	90	90
	Linear	103.5	101.5	101	102

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	70.5	68	72.5	71	70	
	Linear	95	95	92	93	93	
Full Power	dBA	75	75.5	77	74	76	65
	Linear	94	91.5	91.5	92.5	87	83
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	85	86	86	88	78	72
	125	82	78	83	82	81.5	63
	250	80	79.5	84.5	81	77	64
	500	69	69	71.5	73	70	53
	1000	68	69	68	71	71	48
	2000	69	68	68	70	70.5	50
	4000	64	68	67	65	64	48
	8000	65	64	67	65	67	40



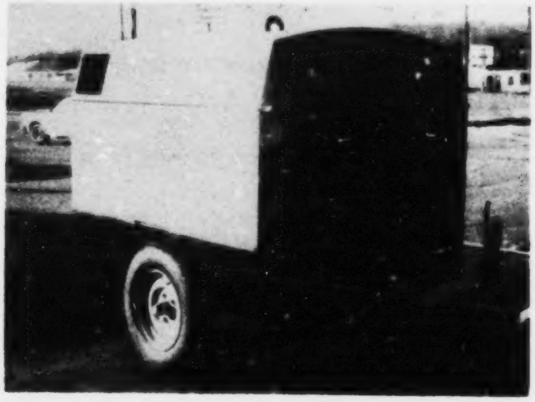


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO



COMPRESSOR

Type: Reciprocal
Model: VSS-125 Dd (Silenced)
Serial: 51-345060
Capacity: 125 cfm

ENGINE

Make: Deutz F3L 919
Horsepower: 37
Rated Speed: 1750 rpm

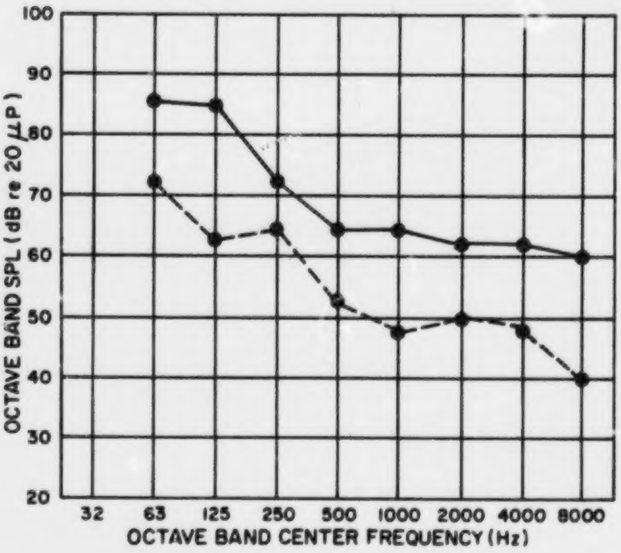
Test Date:
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 10 mph
Temperature: 20° F

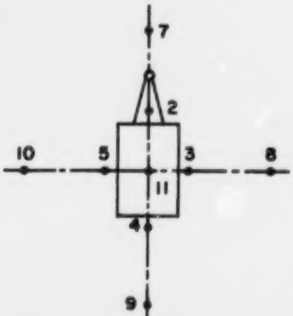
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	69	69	70.5	71
	Linear	100	101	101	100
Full Power	dBA	82.5	79	81.5	81
	Linear	103	105	104	105

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	67	68	68	68	67	
	Linear	95	98	97	96	86	
Full Power	dBA	71	68	69	70	72.5	63
	Linear	98	100	100	98	94	85
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	84	84	36	90	86	72
	125	81	82.5	85	88	85.5	63
	250	70	70	70	72.5	72	64
	500	68	68	62	67	64	53
	1000	60	60	61	63	64	48
	2000	62	60	59	61	62	50
	4000	63	59	58	57	62	48
	8000	61	58	58	55	60	40





Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO

COMPRESSOR

Type: Reciprocal
Model: STS 35 Dd (Silenced)
Serial: ARP 550924
Capacity: 125 cfm

ENGINE

Make: Deutz F3L 912
Horsepower: 40
Rated Speed: 1750 rpm

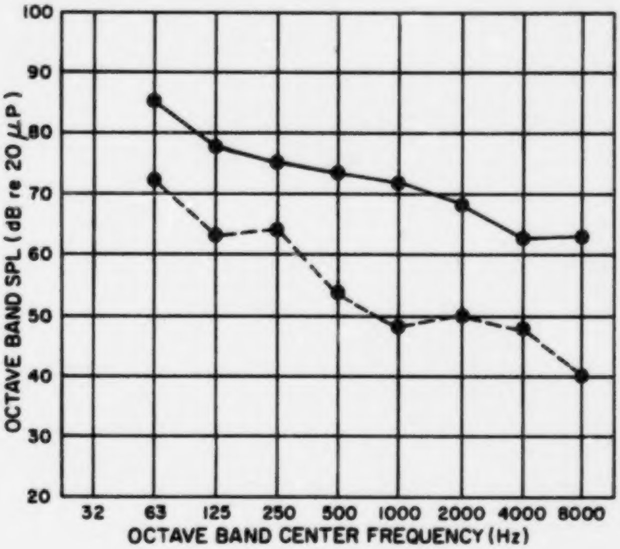
Test Date:
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 10 mph
Temperature: 25° F

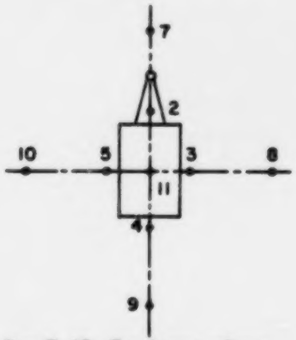
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	80	79	80	81
	Linear	103	102.5	101.5	102.5
Full Power	dBA	86	84.5	84	87.5
	Linear	101.5	102	101.5	102

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	69	68	69	69	69	
	Linear	96	96	96	95.5	92.5	
Full Power	dBA	72	73.5	71	74	77	65
	Linear	100	98	99	97	91	83
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	87	84	78	86	85	72
	125	83	79	77	76	78	63
	250	73	69	70	72	75	64
	500	68	68.5	68	69	72.5	53
	1000	64	68	68	69	71	48
	2000	64	65	64	65	68	50
	4000	61	60	62	61	62	48
	8000	61	60	61	61	62	40



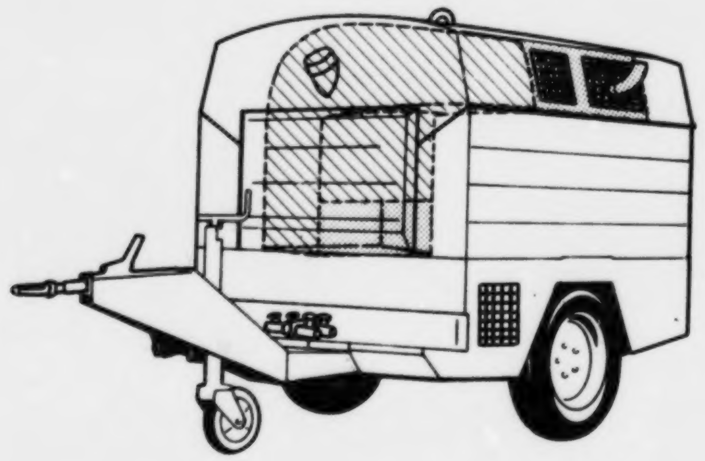


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: ATLAS COPCO



COMPRESSOR

Type: Reciprocal
Model: VSS-170 Dd (Silenced)
Serial: 51-235072
Capacity: 170 cfm, 100 psi

ENGINE

Make: Deutz F4L 912
Horsepower: 50
Rated Speed: 1750 rpm

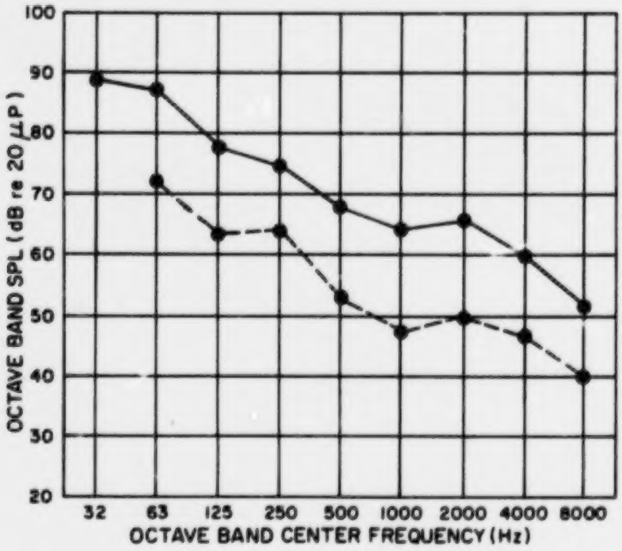
Test Date: 2/28/74
Test Type: Mod. CAGI/PNEUROP
Surface:
Wind:
Temperature:

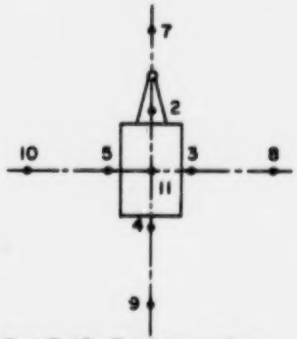
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	70.5	69.5	72	73
	Linear	95	96.5	96.5	94.5
Full Power	dBA	76.5	79	78	82
	Linear	101	101.5	103	106

SEVEN-METER LEVELS

Pos. Level		7	8	9	10	11	Bkgd.
Idle	dBA	61	61	61.5	61	61	
	Linear	85.5	88.5	87.5	88.5	82	
Full Power	dBA	70	69	73	70.5	68.7	65
	Linear	91	93	92	92.5	93	83
Full Power	O.B.Ctr Freq(Hz)						
	32	87.5	90	89	90.5	91	
	63	87.5	90	87.5	87.5	89	72
	125	76.5	81.5	77.5	79	78	63
	250	71	69	74.5	75.5	70	64
	500	66.5	65	68	67.5	66	53
	1000	62.5	60	64.5	61	62	48
	2000	62	55.5	65.5	58.5	59	50
	4000	52.5	48	59.5	51	49	48
	8000	45.5	40	51.5	49	39	40





Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: WORTHINGTON

COMPRESSOR

Type: Vane
Model: 160 G/2 QT (Silenced)
Serial: 821-478
Capacity: 160 cfm

ENGINE

Make: IH
Horsepower: 65
Rated Speed: 2400 rpm

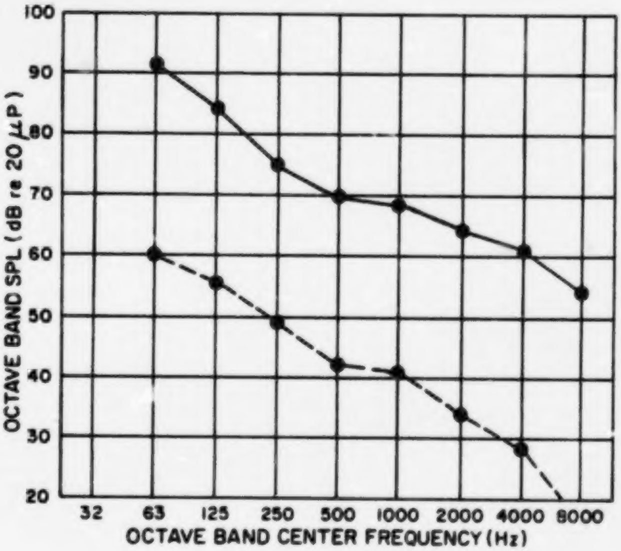
Test Date: 1/29/74
Test Type: Mod. CAGI/PNEUROP
Surface: Blacktop
Wind: <5 mph
Temperature: 38° F

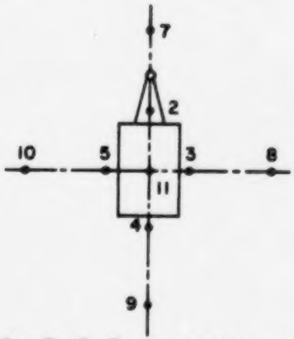
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	78	76	74	77
	Linear	89	93	94	89
Full Power	dBA	83	86	84	85
	Linear	89	93	95	96

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	69	67	43	67	65	
	Linear	85	83	55	86	81	
Full Power	dBA	74	75	74	76	72	46
	Linear	90	92	87	93	84	68
Full Power	O.B.Ctr Freq(Hz)						
	32						
	63	89	91	88	91	85	60
	125	80	83	80	84	76	56
	250	76	78	74	76	71	49
	500	71	70	71	70	70	42
	1000	69	69	67	69	66	41
	2000	61	64	61	64	61	34
	4000	55	61	58	61	54	29
	8000	50	57	49	54	54	15



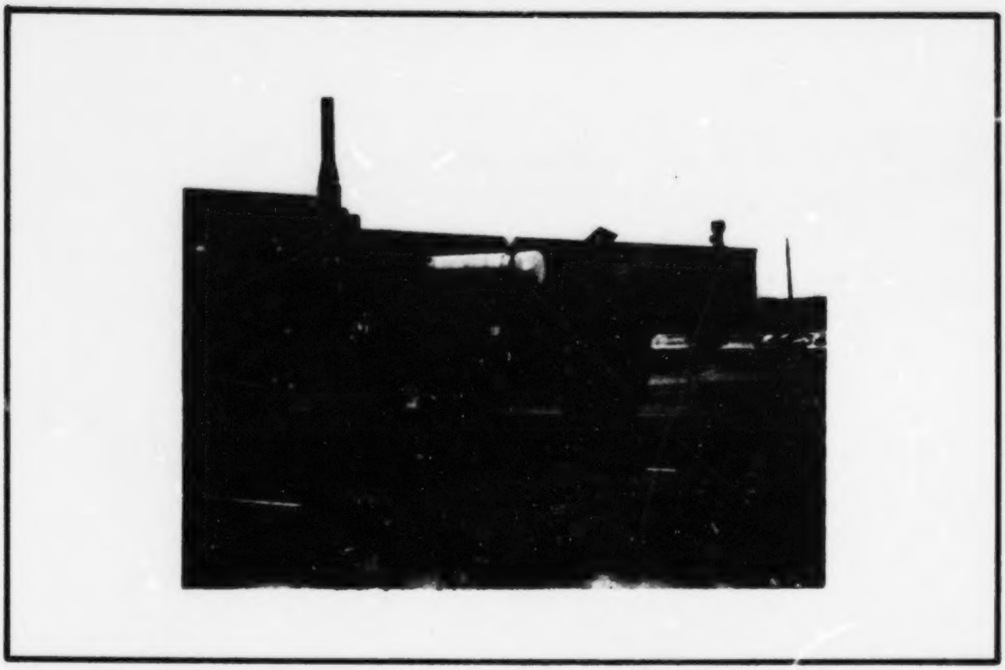


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: WORTHINGTON



COMPRESSOR

Type: Screw
Model: 750S-QTEX (Silenced)
Serial: 848.019
Capacity: 750 cfm, 110 psi

ENGINE

Make: GMDD 6V-71
Horsepower: 210
Rated Speed: 2100 rpm

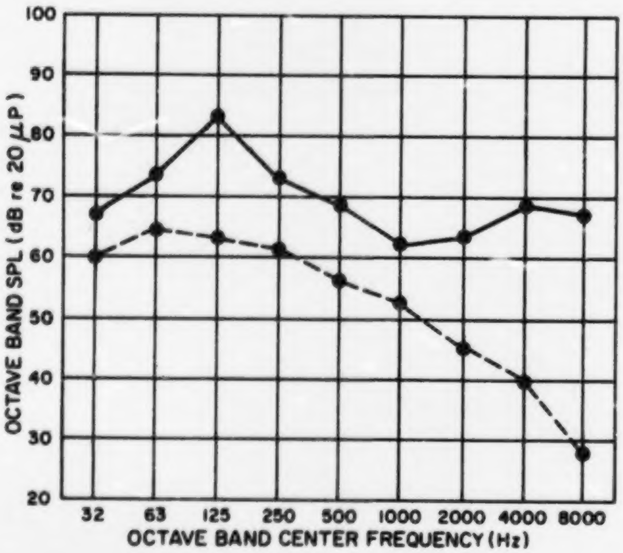
Test Date: 2/25/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 28° F

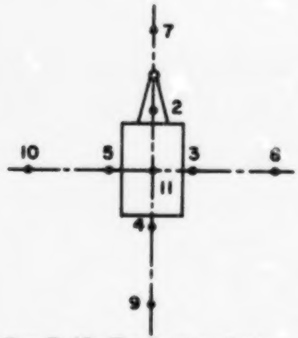
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	76	80	74	79
	Linear	86.5	89	86	87
Full Power	dBA	83.5	86	81.5	85
	Linear	89.5	94	94	92

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	65.5	69.5	66	68	66	58.5
	Linear	80	84	82	82	82	69
Full Power	dBA	74.5	74	71.5	72.5	72.5	
	Linear	84	83	83	81	82	
Full Power	O.B.Ctr Freq(Hz)						
	32	66	65	67	67	63	60
	63	73	70	73.5	69.5	71	65
	125	82.5	78.5	81.5	76.5	75.5	64
	250	72.5	78	72.5	75.5	75.5	61.5
	500	69.5	72	70.5	71.5	71	56
	1000	62	69	63	67	66	52.5
	2000	63.5	60	58.5	62	62.5	45
	4000	68.5	59.5	58.5	58	59	40
	8000	68	54	54.5	53.5	55	27.5





Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND

COMPRESSOR

Type: Rotary-Screw
Model: DXL 1200*
Serial: 74430
Capacity: 1200 cfm
* Doors Closed

ENGINE

Make: GMDD 12V-71N
Horsepower: 420
Rated Speed: 2100 rpm

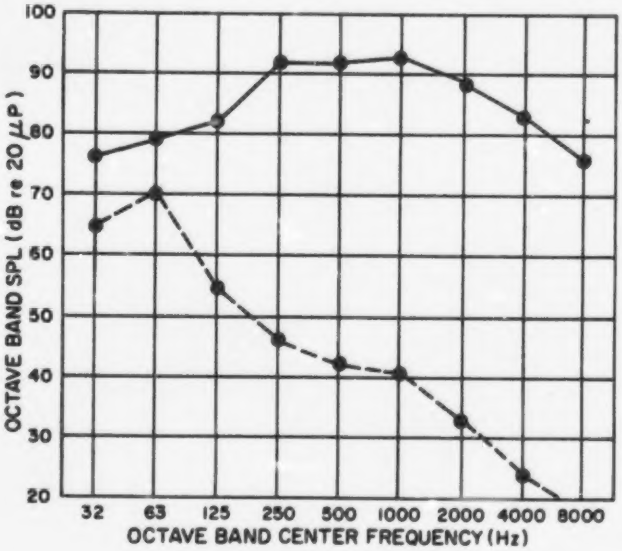
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 45° F

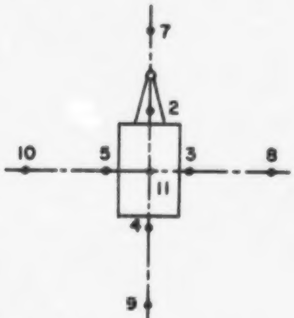
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	97	94	90	94
	Linear	99	96.5	94	96.5
Full Power	dBA	107	102.5	99	103.5
	Linear	108.5	105	102	106.5

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	86	83	91.5	83.5		
	Linear	88.5	87	96.5	88.5		
Full Power	dBA	96	92	90.5	92		47
	Linear	98	95	94.5	95.5		69
Full Power	O.B.Ctr Freq(Hz)						
	32	76.5	77.5	73.5	74		64
	63	79	80.5	76	79.5		70.5
	125	82	87	83.5	85.5		54.5
	250	92	88.5	88	88		47
	500	92	93	89.5	92		41.5
	1000	93	89	89	88		40.5
	2000	88.5	84	82	84		33
	4000	82.5	78	74.5	77.5		24
	8000	76.5	71.5	67.5	71		19



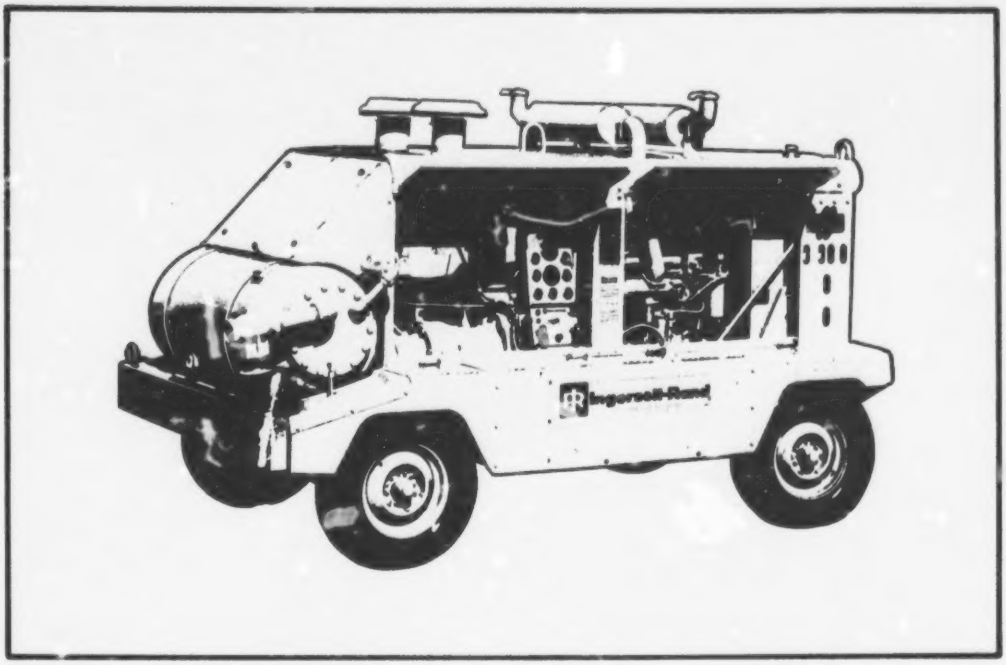


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw

Model: DXL 1200 (Doors Open)

Serial: 74430

Capacity: 1200 cfm

ENGINE

Make: GMDD 12V-71N

Horsepower: 420

Rated Speed: 2100 rpm

Test Date: 2/11/74

Test Type: Mod. CAGI/PNEUROP

Surface: Asphalt

Wind: 5 mph

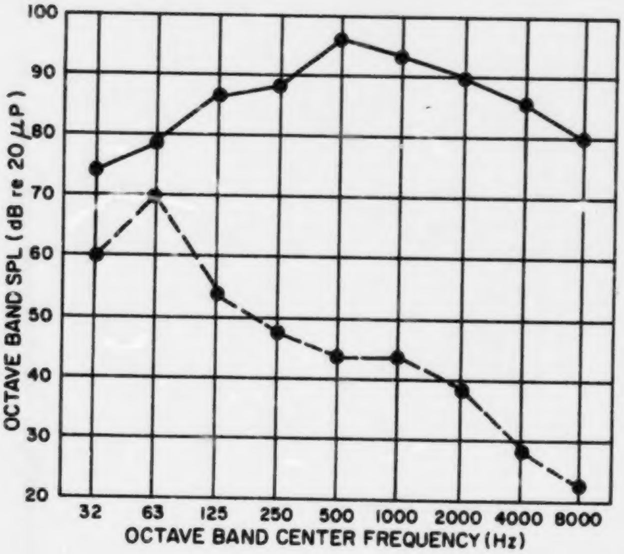
Temperature: 45° F

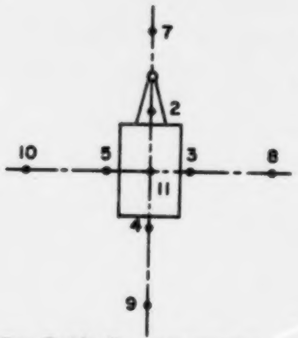
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	96.5	97.5	90	97.5
	Linear	99	98.5	93.5	99.5
Full Power	dBA	106.5	105.5	98.5	107.5
	Linear	108.5	108	101.5	108.5

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	85	87	82	87.5		
	Linear	88	89	86.5	90		
Full Power	dBA	95.5	96.5	91	97		47
	Linear	97.5	97.5	94.5	99.5		69
Full Power	O.B.Ctr Freq(Hz)						
	32	76	76.5	72	74		59
	63	77	78	76.5	78.5		69
	125	81.5	85	83.5	86.5		53.5
	250	92	87.5	86.5	88.5		48
	500	93	93	90.5	96		42.5
	1000	92.5	93	89	93		43.5
	2000	89	89.5	82	90		39
	4000	83	84.5	76	86.5		28.5
	8000	75.5	76.5	68.5	80.5		22.5



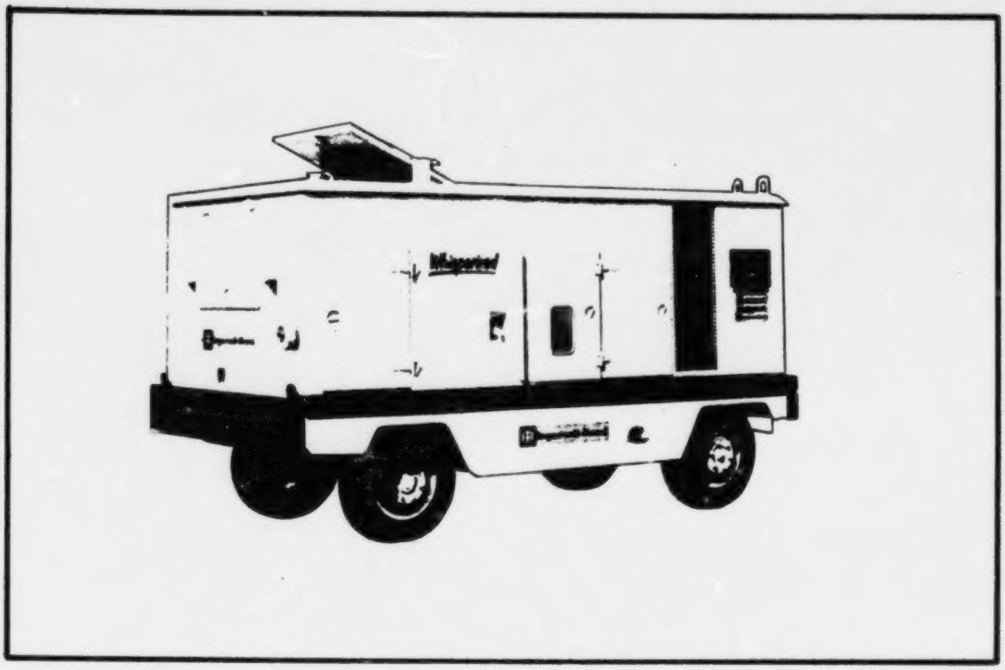


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw
Model: DXL 900S (Silenced)
Serial: 73693
Capacity: 900 cfm, 125 psi

ENGINE

Make: GMDD 8V-71N
Horsepower: 280
Rated Speed: 2100 rpm

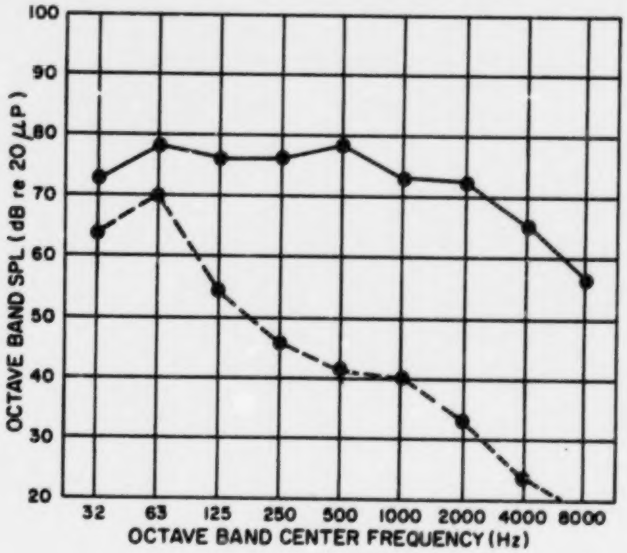
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 45° F

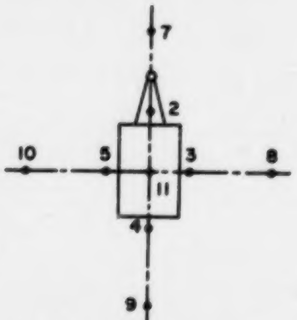
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	73	75	76.5	75
	Linear	91	90	90.5	88.5
Full Power	dBA	80	83.5	82.5	83.5
	Linear	90	91	90	91.5

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	65	68	70	68	65.5	
	Linear	85.5	83.5	84	85	81	
Full Power	dBA	73	76.5	78.5	77	75	47
	Linear	82.5	85	84.5	84.5	82	69
Full Power	O.B.Ctr Freq(Hz)						
	32	73	72	73	75.5	69	64
	63	73	76	78.5	77	74	70.5
	125	74.5	78.5	76.5	79	76.5	54.5
	250	72.5	76	76.5	75	74	47
	500	72.5	76	78.5	74.5	75	41.5
	1000	70	72	73	71.5	72.5	40.5
	2000	67	72	72.5	70.5	67	33
	4000	60	64	65.5	61	59	24
	8000	51.5	56.5	57	52	50.5	19





Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND

COMPRESSOR

Type: Rotary-Screw
Model: DXL 900S (Silenced)
Serial: 74050
Capacity: 900 cfm, 125 psi

ENGINE

Make: GMDD 8V-71N
Horsepower: 280
Rated Speed: 2100 rpm

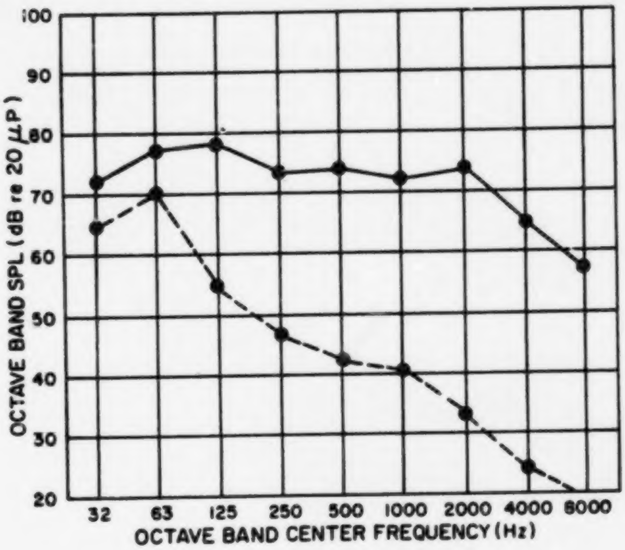
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 50° F

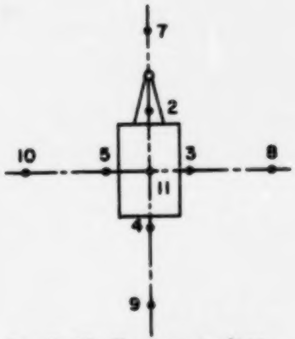
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	73	76	76.5	76
	Linear	86.5	94	91.5	92
Full Power	dBA	80	82.5	83	82.5
	Linear	87.5	89.5	90.5	89.5

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	64.5	68	69	68.5	67	
	Linear	82	87	85.5	86	82	
Full Power	dBA	72.5	75.5	76.5	76.5	74.5	47
	Linear	82	82	83	83.5	79.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	73	69.5	71.5	72	67	64
	63	72.5	75	76.5	77.5	70.5	70.5
	125	74	74.5	75.5	78	73	54.5
	250	69.5	73	75.5	73.5	73	47
	500	74.5	75	78.5	74	75.5	41.5
	1000	69	72.5	72	71.5	73	40.5
	2000	65	70	71	73	67.5	33
	4000	57	63.5	65	66	59	24
	8000	47.5	55.5	58	57.5	52	19





Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND

COMPRESSOR

Type: Rotary-Screw
Model: DXLCU 1050
Serial: 75613
Capacity: 1050 cfm, 125 psi

ENGINE

Make: Cummins V-903
Horsepower: 307
Rated Speed: 2600 rpm

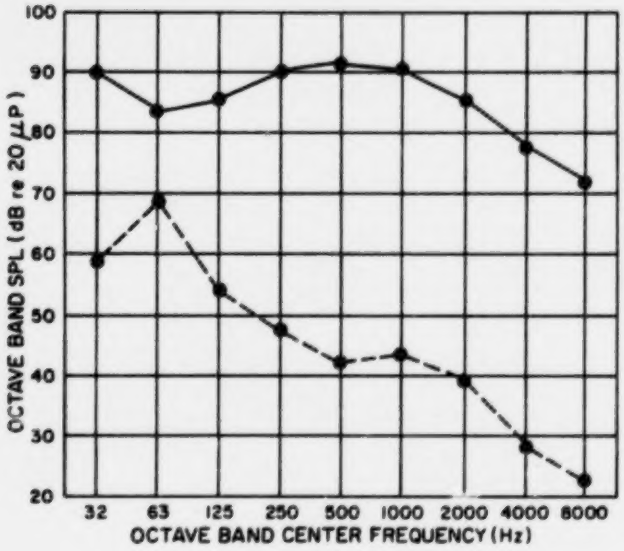
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 50° F

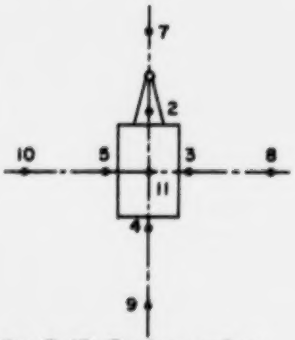
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	94.5	91	88.5	92
	Linear	97.5	96.5	96.5	102
Full Power	dBA	104	101	97.5	100.5
	Linear	107.5	106	102	107

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	82.5	82.5	79.5	82.5	79	
	Linear	88.5	89.5	91.5	97	94.5	
Full Power	dBA	92	91	88.5	90.5	89	47
	Linear	96	99.5	95	100.5	95.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	89.5	90	87.5	89.5	89.5	59
	63	83.5	95.5	89.5	98	90.5	69
	125	86.5	87.5	87	87.5	89	53.5
	250	89.5	84.5	87	85	89	48
	500	91	89.5	87	88.5	87	42.5
	1000	90.5	89	87.5	89.5	87	43.5
	2000	86	82.5	80.5	84	80.5	39
	4000	78.5	77.5	73	77.5	73	28.5
	8000	71.5	68.5	65	70.5	67.5	22.5



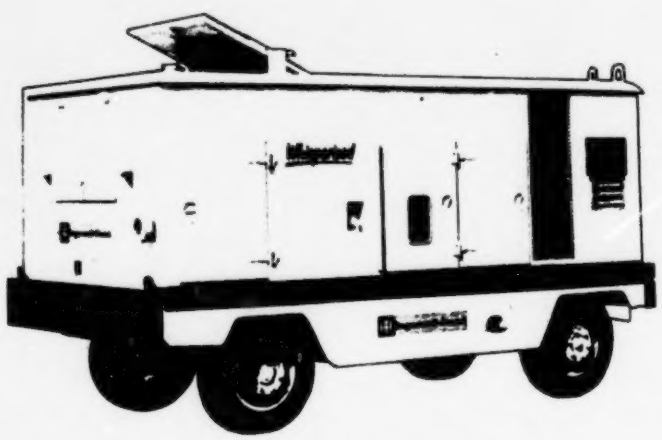


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw

Model: DXL 900S (Silenced)

Serial: 74051

Capacity: 900 cfm, 125 psi

ENGINE

Make: GMDD 8V-71N

Horsepower: 280

Rated Speed: 2100 rpm

Test Date: 2/12/74

Test Type: Mod. CAGI/PNEUROP

Surface: Asphalt

Wind: 65 mph

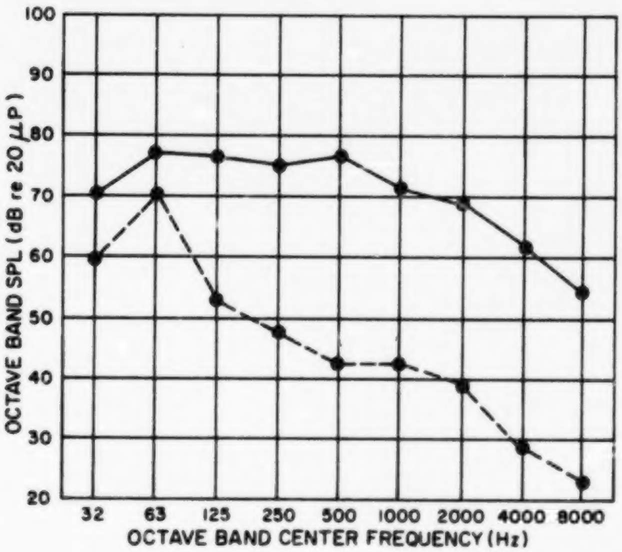
Temperature: 40° F

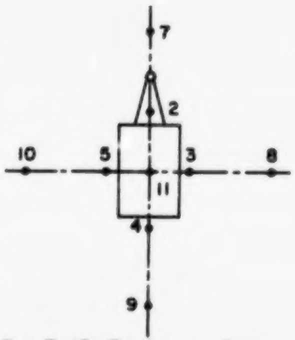
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	75	77.5	77	77
	Linear	85.5	91	87	88.5
Full Power	dBA	81	83.5	83.5	84.5
	Linear	87.5	91	90.5	92

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	65.5	69	69.5	69.5	66.5	
	Linear	79	84.5	82	85.5	75	
Full Power	dBA	73	76.5	77	76.5	73.5	47
	Linear	82.5	83.5	83.5	84.5	81.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	69.5	70	70.5	69.5	66	59
	63	71	73.5	76	75	71.5	69
	125	74.5	78.5	75.5	77	76.5	53.5
	250	71.5	74.5	74	73.5	72.5	48
	500	71.5	73.5	76.5	77	74	42.5
	1000	67.5	71.5	71.5	70.5	51	43.5
	2000	63.5	69	69.5	69	65.5	39
	4000	56.5	62	63	60	57	28.5
	8000	47.5	52.5	54	51	49.5	22.5



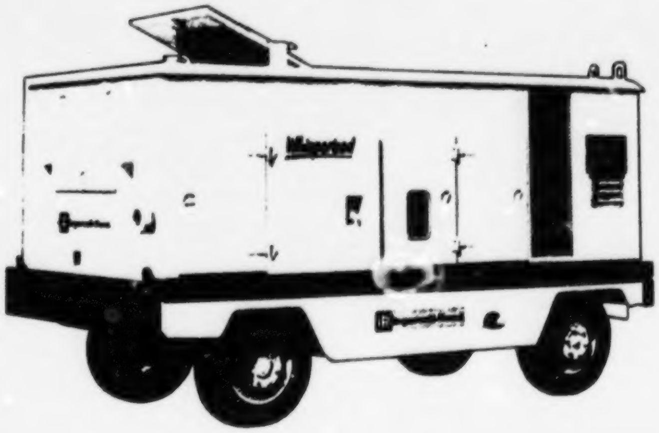


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw
Model: DXL 900S (Silenced)
Serial: 740471
Capacity: 900 cfm, 125 psi

ENGINE

Make: GMDD 8V-71N
Horsepower: 280
Rated Speed: 2100 rpm

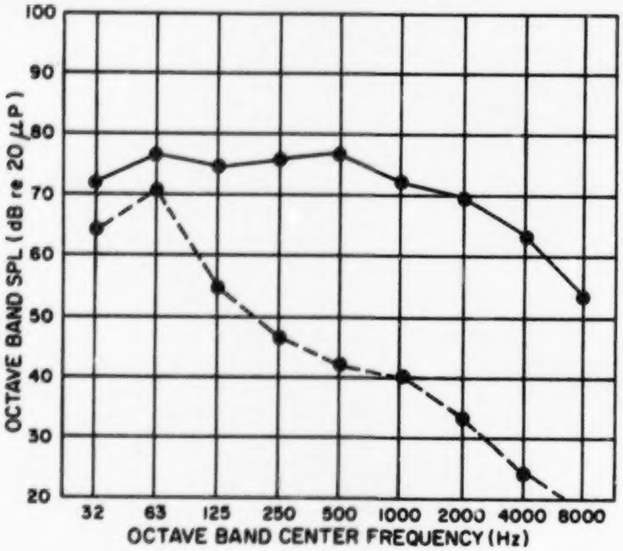
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 50° F

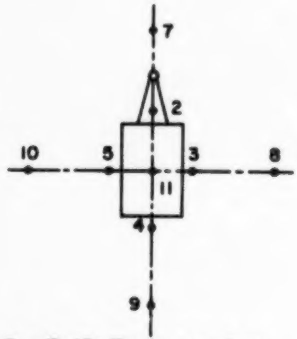
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	72.5	75.5	75	74.5
	Linear	84.5	91	89	86
Full Power	dBA	80	83	83	83.5
	Linear	87	90.5	91	90

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	63	69	68	67	66	
	Linear	79	85	83	83	78	
Full Power	dBA	72	76.5	77	75.5	74	47
	Linear	80.5	84	94	83	80.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	70.5	71	72	73	68.5	64
	63	72	77.5	76.5	72.5	68.5	70.5
	125	73.5	78	74.5	77.5	74.5	54.5
	250	70.5	76.5	75	75.5	71	47
	500	72	75	77	74.5	74.5	41.5
	1000	66	71	71.5	69.5	69	40.5
	2000	63	71	69.5	68.5	64	33
	4000	54	63	63	60	55	24
	8000	43.5	53	53.5	50	48.5	19



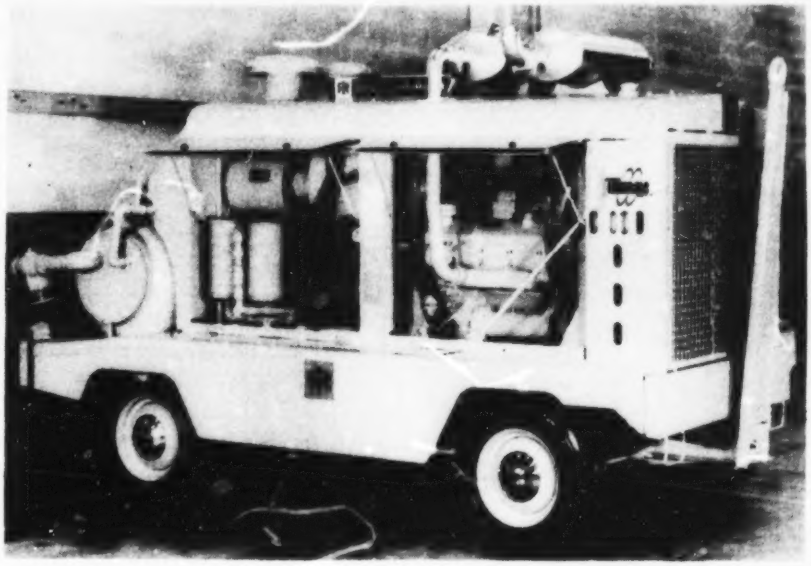


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw
Model: DXL 900
Serial: 75847
Capacity: 900 cfm, 125 psi

ENGINE

Make: GMDD 8V-71N
Horsepower: 280
Rated Speed: 2100 rpm

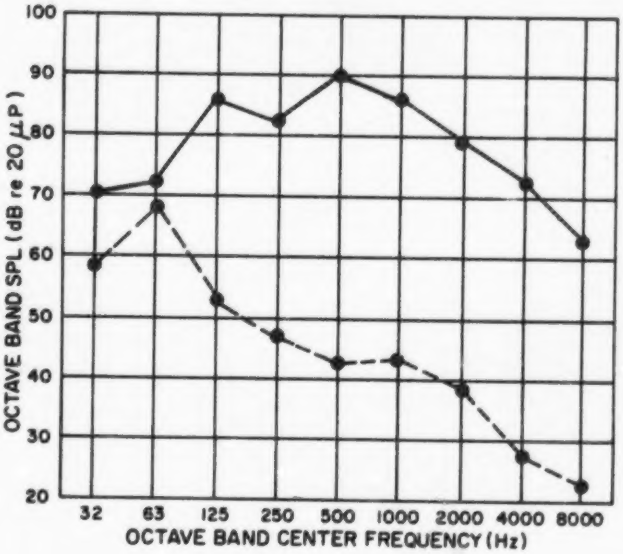
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 60° F

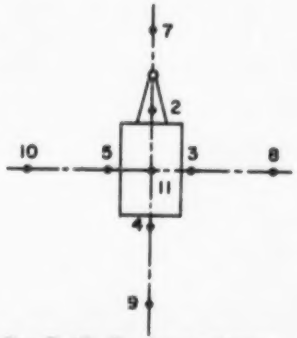
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	92	89.5	87	91
	Linear	96	94.5	92	97
Full Power	dBA	100	98	95	98.5
	Linear	103.5	101	97.5	102

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	81	80	78	81	81.5	
	Linear	87	86	87	90.5	89.5	
Full Power	dBA	91	90.5	88	91	89	47
	Linear	93.5	92.5	91	94	93.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	68	68	67.5	71	67.5	59
	63	76	75.5	73.5	72.5	76.5	69
	125	81	84.5	85.5	86.5	86.5	53.5
	250	84.5	80	79.5	82.5	86	48
	500	90	89.5	85	90	90.5	42.5
	1000	87.5	87.5	83.5	86.5	86	43.5
	2000	81	78.5	75.5	79.5	79	39
	4000	74	72	65	73	70	28.5
	8000	64.5	61	54	63	61	22.5



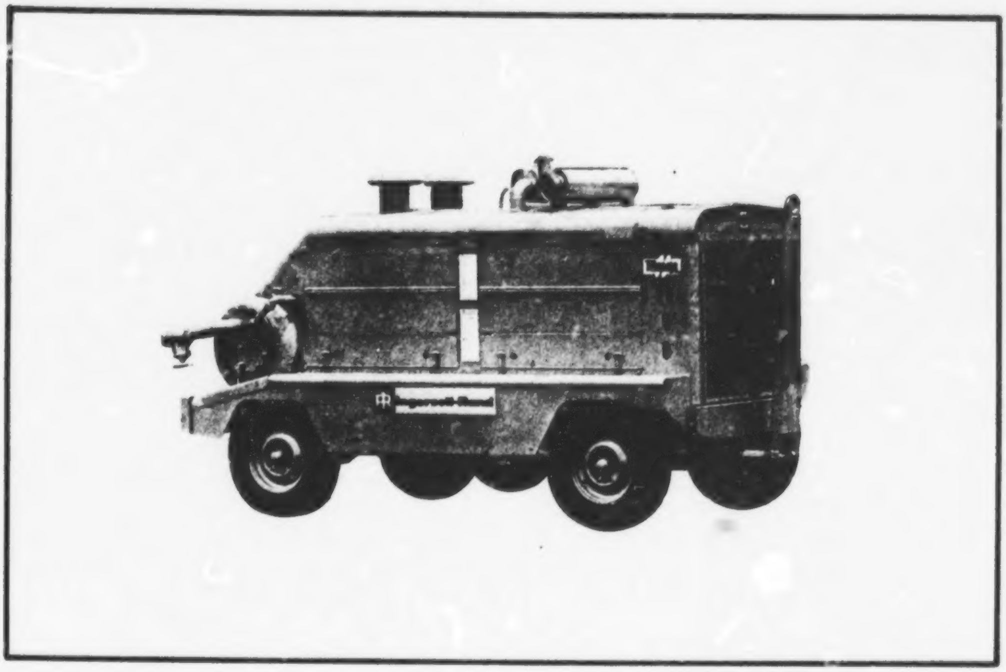


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: INGERSOLL-RAND



COMPRESSOR

Type: Rotary-Screw
Model: DXL 750
Serial: 77380
Capacity: 750 cfm, 125 psi

ENGINE

Make: GMDD 6V-71N
Horsepower: 228
Rated Speed: 2100 rpm

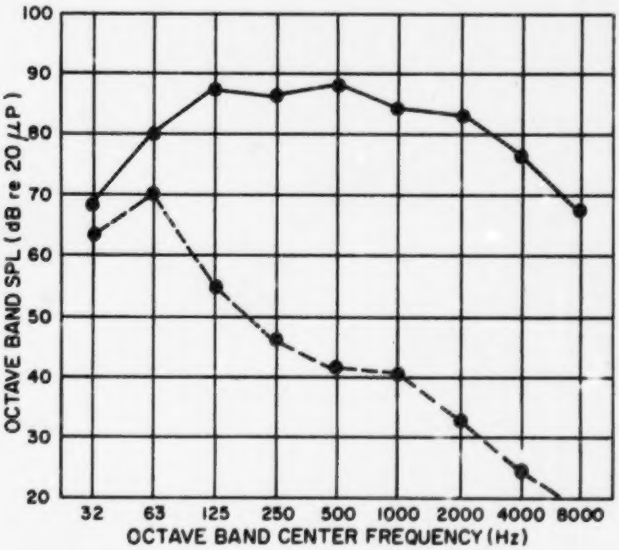
Test Date: 2/11/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 5 mph
Temperature: 60° F

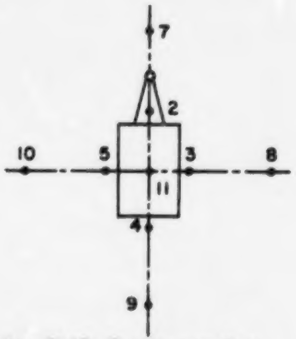
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	91	91	87	90.5
	Linear	96	97.5	93	97.5
Full Power	dBA	101	98	96.5	99
	Linear	104	102	99.5	104

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	79	78.5	77.5	78	77.5	
	Linear	87.5	87	87.5	87.5	87	
Full Power	dBA	89	87	86.5	88	88	47
	Linear	93.5	92.5	91.5	95	90.5	69
Full Power	O.B.Ctr Freq(Hz)						
	32	68.5	69	66.5	70	69	64
	63	79.5	82	78	80.5	78.5	70.5
	125	87.5	88.5	86.5	92.5	84.5	54.5
	250	86.5	81.5	81.5	81.5	81.5	47
	500	88	86	90	89	83.5	41.5
	1000	84	84.5	82	84.5	83	40.5
	2000	82.5	79.5	78	79.5	76.5	33
	4000	76.5	73.5	70.5	73.5	68.5	24
	8000	67	66	60.5	64.5	61	19





Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: GARDNER-DENVER

COMPRESSOR

Type: Rotary-Screw
Model: SPWDA/2 (Silenced)
Serial: 635851
Capacity: 1200 cfm, 100 psi

ENGINE

Make: GMDD 12V-71N
Horsepower: 400
Rated Speed: 1850 rpm

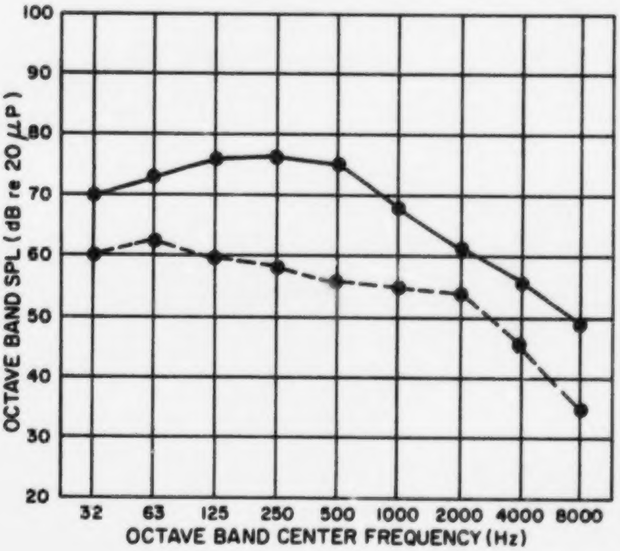
Test Date: 2/14/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-10 mph
Temperature: 32° F

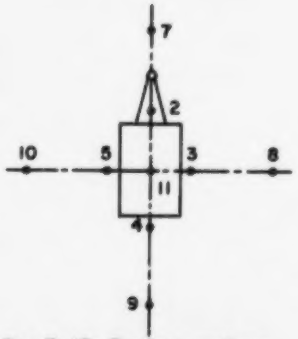
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	76.5	75.5	73.5	77.5
	Linear	89.5	89	86	89
Full Power	dBA	83.5	81	89	83
	Linear	96	88	89	89

SEVEN-METER LEVELS

Level / Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	67.5	69	65.5	68.5	64	
	Linear	82	84	81.5	81.5	75	
Full Power	dBA	73.5	75	72	74.8	73	65
	Linear	86	83	83.5	83.5	81	72
Full Power	O.B.Ctr Freq(Hz)						
	32	76.5	69.5	68	69	66	60
	63	81	73	76	73.5	72	62
	125	81.5	76.5	77.5	77.5	70	60
	250	73	77	71.5	74.5	70	58
	500	71	76	71	75	73	56
	1000	67	68.5	65	68	63	55
	2000	61.5	61.5	59	62	58	54
	4000	52.5	56.5	55.5	57	52.5	46
	8000	47.5	49.5	53	51	48	35





Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: GARDNER-DENVER

COMPRESSOR

Type: Rotary-Screw
Model: SPQDA/2 (Silenced)
Serial: 608227
Capacity: 750 cfm, 100 psi

ENGINE

Make: GMDD 6-71N
Horsepower: 228
Rated Speed: 2100 rpm

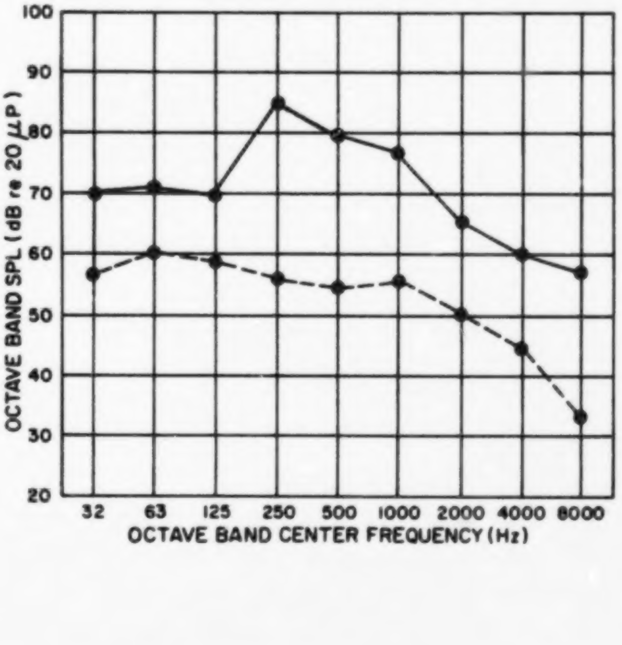
Test Date: 2/14/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-10 mph
Temperature: 32° F

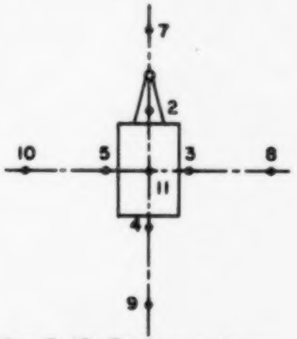
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	77	79.5	77.5	83.5
	Linear	89	90	87	89.5
Full Power	dBA	85.5	83.5	86.5	89
	Linear	95.5	89	97	93

SEVEN-METER LEVELS

Level	Pos.	7	8	9	10	11	Bkgd.
Idle	dBA	67.5	70.5	70	71.5	71.5	
	Linear	81.5	81.5	81	83.5	81	
Full Power	dBA	76	77	80.5	79.5	78	65
	Linear	84	84	89	88	83	72
Full Power	O.B.Ctr Freq(Hz)						
	32	67	70	69.5	74.5	70	57
	63	70.5	68	70.5	71	66.5	61
	125	72	67	69.5	68	69	58.5
	250	79	76	84.5	74.5	77.5	56.5
	500	73	74	79	79	76	54.5
	1000	72	75	77	75.5	72	55.5
	2000	66.5	65	65.5	69.5	70	51
	4000	58	58.5	60.5	62.5	62	45.5
	8000	55.5	54	57.5	57	56.5	33



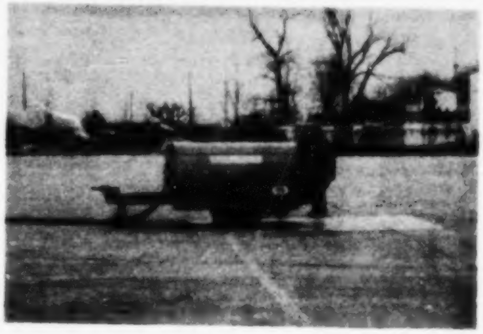


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: GARDNER-DENVER



COMPRESSOR

Type: Rotary-Screw
Model: SPHGC (Silenced)
Serial: 629717
Capacity: 185 cfm, 100 psi

ENGINE

Make: Ford (Gas) 6 cyl.
Horsepower: 82
Rated Speed: 2400 rpm

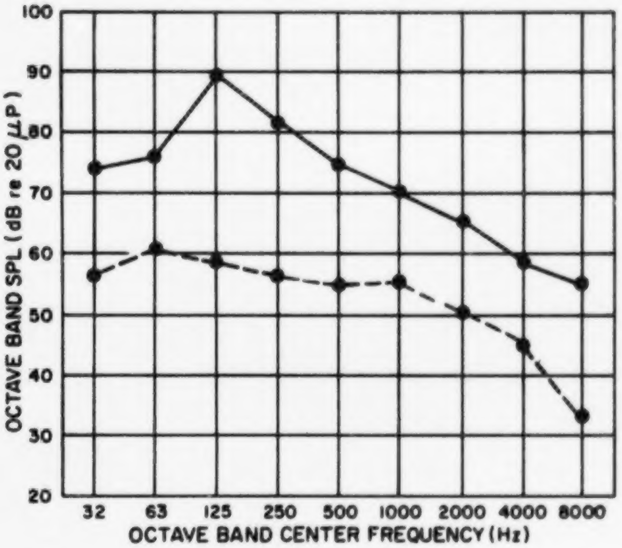
Test Date: 2/14/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-10 mph
Temperature: 40° F

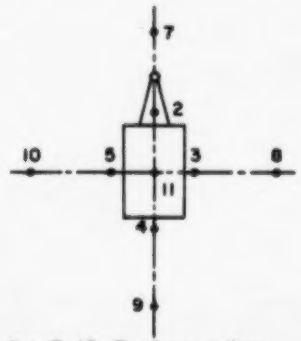
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	75.5	76	77	76
	Linear	95.5	96	93.5	96.5
Full Power	dBA	87.5	86.5	87	87
	Linear	99	98.5	96	99

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	66.5	67	68	66	66	
	Linear	83	86	85	85	85	
Full Power	dBA	77.5	77	78	78	75	65
	Linear	87	91	88.5	90.5	89	72
Full Power	O.B.Ctr Freq(Hz)						
	32	67.5	70	73	74	62.5	57
	63	74.5	77	70.5	77	70	61
	125	81	90	86	89.5	89.5	58.5
	250	83.5	79.5	82	81.5	77	56.5
	500	76	74.5	76	75	73.5	54.5
	1000	71	70.5	72	70.5	70	55.5
	2000	65.5	65.5	63.5	66	66.5	51
	4000	59.5	59.5	58	59	57.5	45.5
	8000	53	55	53.5	55.5	50.5	33



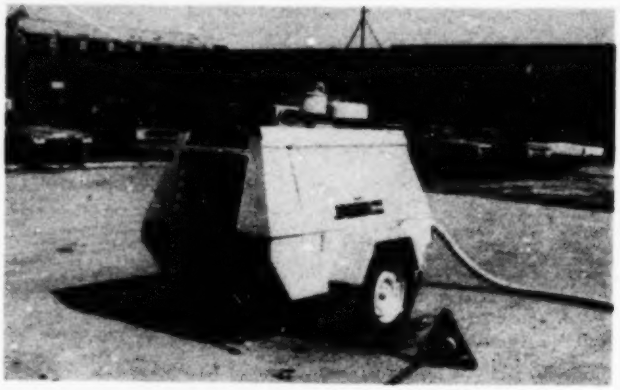


Pos. 7-10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2-5: 1m from surface, 1.5m above plane

MANUFACTURER: JAEGER



COMPRESSOR

Type: Rotary-Screw
Model: A
Serial: RS 32189
Capacity: 175 cfm

ENGINE

Make: White (Gas)
Horsepower: 76
Rated Speed: 2200 rpm

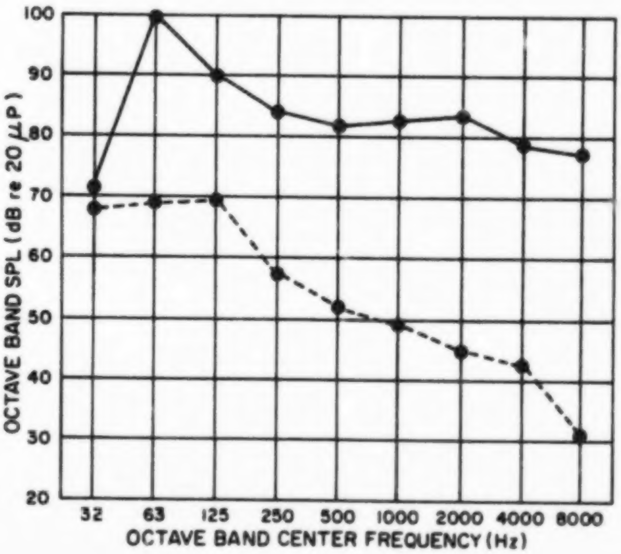
Test Date: 2/15/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-5 mph
Temperature: 40° F

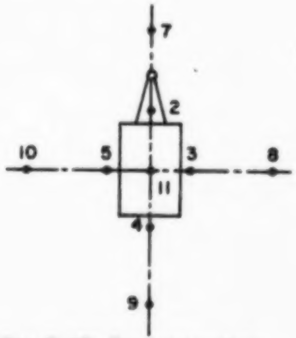
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	89	91	91.5	89.5
	Linear	101.5	105	101.5	102
Full Power	dBA	97.5	99	101	98
	Linear	106	107	107.5	104.5

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	77.5	79.5	80	78	80	
	Linear	96.5	97	97.5	96	100	
Full Power	dBA	87	88.5	89.5	88	88	
	Linear	102	101	102	98.5	105.5	
Full Power	O.B.Ctr Freq(Hz)						
	32	71	72.5	71.5	71	69.5	68
	63	100	99	100	96	103.5	69
	125	92.5	92.5	90	87	96.5	69.5
	250	82.5	87	84.5	87.5	90.5	58
	500	83	80	82	80.5	86.5	52.5
	1000	82	80	82.5	80.5	81.5	49.5
	2000	81.5	73.5	83	83	78	45
	4000	78	78	79	78.5	71.5	43
	8000	78	78	77.5	78	68.5	30.5





Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: JAEGER

COMPRESSOR

Type: Rotary-Screw
Model: A (Doors Open)
Serial: RS 83189
Capacity: 175 cfm, 100 psi

ENGINE

Make: White (Gas)
Horsepower: 76
Rated Speed: 2200 rpm

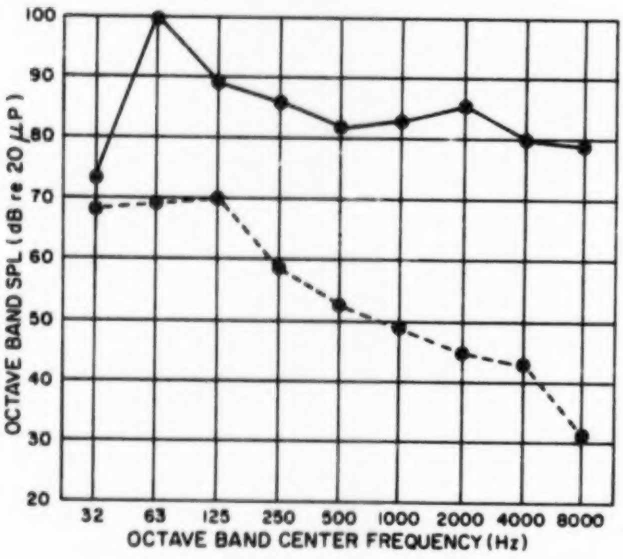
Test Date: 2/15/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-5 mph
Temperature: 40° F

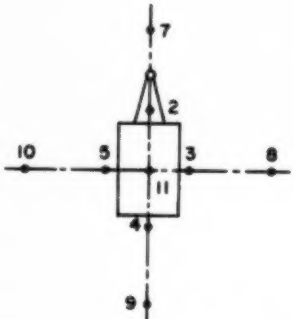
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	88.5	94.5	90.5	93
	Linear	101.5	104	102	103
Full Power	dBA	97	101	100.5	100.5
	Linear	107.5	108	107.5	107

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	77.5	81	79.5	80	80.5	
	Linear	96.5	96.5	97	96.5	100	
Full Power	dBA	87	90	89.5	89.5	89.5	
	Linear	102	101	101	100.5	105.5	
Full Power	O.B.Ctr Freq(Hz)						
	32	73.5	73.5	73	71.5	71.5	68
	63	100.5	100	99	99	103.5	69
	125	89.5	89.5	89.5	88.5	98.5	69.5
	250	81	86	82.5	88	90.5	58
	500	82	82	83	80.5	85.5	52.5
	1000	81	82.5	83	82	83	49.5
	2000	82.5	85.5	84.5	83.5	79.5	45
	4000	78	80	81	80.5	74	43
	8000	78	79	80.5	79.5	71.5	30.5



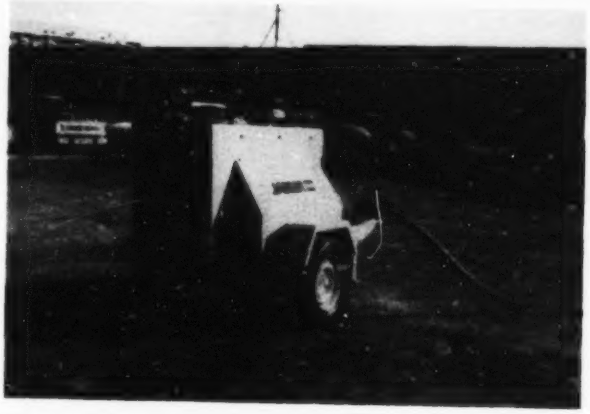


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: JAEGER



COMPRESSOR

Type: Vane
Model: E
Serial: RC-32032
Capacity: 85 cfm, 100 psi

ENGINE

Make: IH (Gas)
Horsepower: 46.5
Rated Speed: 2050 rpm

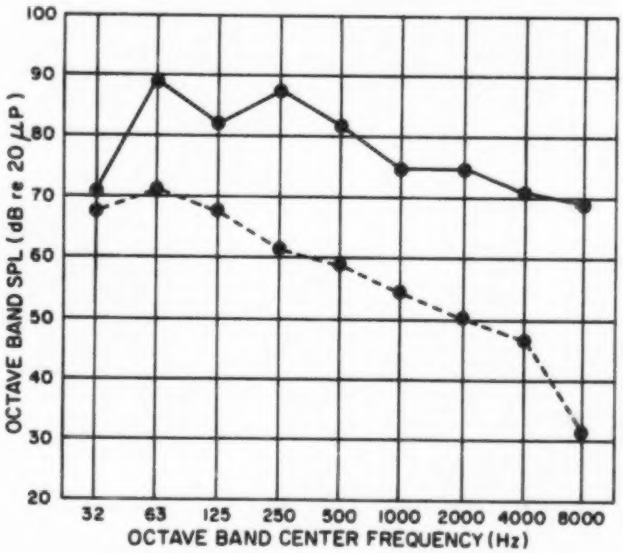
Test Date: 2/15/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-10 mph
Temperature: 32° F

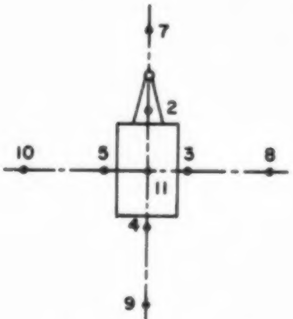
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	83	81	83	80
	Linear	95.5	97	96	97
Full Power	dBA	93	91	95	91
	Linear	102.5	103	103	102

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	70	70	71.5	70.5	72	
	Linear	90	89.5	89.5	89	89	
Full Power	dBA	80	79.5	83.5	80.5	84	
	Linear	92	94.5	95	94.5	94	
Full Power	O.B.Ctr Freq(Hz)						
	32	68.5	69.5	69.5	69.5	71	67.5
	63	88.5	90.5	90.5	91	89	71.5
	125	82.5	84.5	88	85	82	68
	250	80	82.5	86.5	81.5	87.5	61.5
	500	75	73	74	73	82	59
	1000	72.5	70.5	76	71.5	75	55
	2000	69	70.5	73.5	71.5	74.5	50.5
	4000	69	71.5	73.5	73	71	47
	8000	68.5	70	72.5	70.5	69	31.5



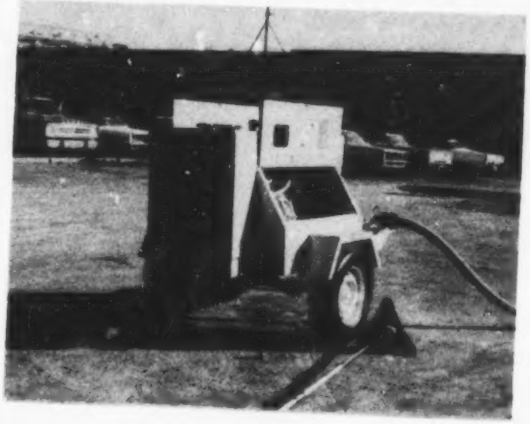


Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

MANUFACTURER: JAEGER



COMPRESSOR

Type: Vane
Model: E (Doors Open)
Serial: RC-32032
Capacity: 85 cfm, 100 psi

ENGINE

Make: IH (Gas)
Horsepower: 46.5
Rated Speed: 2050 rpm

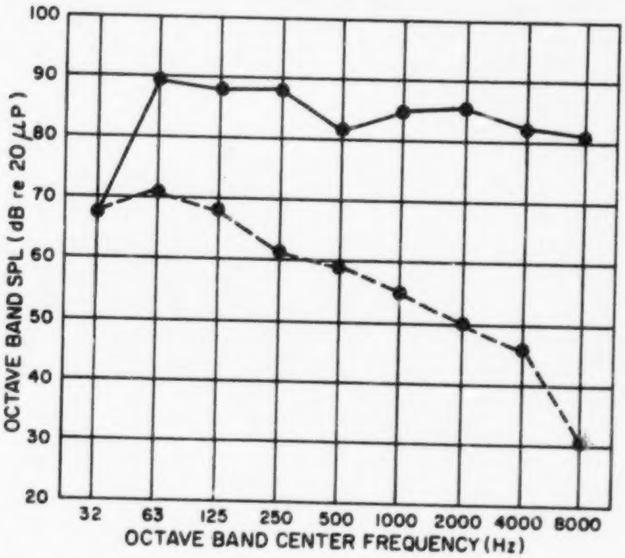
Test Date: 2/15/74
Test Type: Mod. CAGI/PNEUROP
Surface: Asphalt
Wind: 0-10 mph
Temperature: 32° F

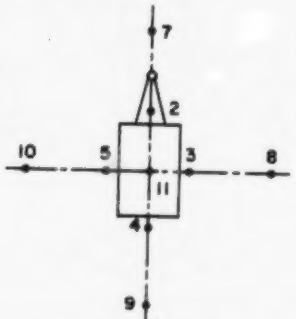
ONE-METER LEVELS

Level \ Pos.		2	3	4	5
Idle	dBA	82	85.5	82.5	82
	Linear	96	97	96	97
Full Power	dBA	93.5	96	95.5	95
	Linear	104	105.5	105	106

SEVEN-METER LEVELS

Level \ Pos.		7	8	9	10	11	Bkgd.
Idle	dBA	70	73	71	71.5	72	
	Linear	90.5	90	90	92	88	
Full Power	dBA	80	83	83	82	85	
	Linear	93	95.5	95	96	96	
Full Power	O.B.Ctr Freq(Hz)						
	32	71.5	72	84	71.5	67.5	67.5
	63	88.5	91.5	92	91.5	89.5	71.5
	125	83.5	88.5	88.5	89	88.5	68
	250	84.5	83	88	85.5	88.5	61.5
	500	74.5	74.5	75.5	76	82	59
	1000	72	75	76.5	73.5	85.5	55
	2000	69.5	73.5	74.5	72.5	85.5	50.5
	4000	70	77	74	72.5	83	47
	8000	68.5	76	73	71.5	81	31.5





Pos. 7–10: 7m from surface, 1.2m above plane

Pos. 11: 7m above surface

Pos. 2–5: 1m from surface, 1.5m above plane

APPENDIX D:*

EXCERPTS FROM THE MEASUREMENT STANDARD FOR PORTABLE COMPRESSORS
ISO 2151-1972
ANSI S5.1-1971
CAGI/PNEUROP

6.0 Procedure for Sound Level Measurement for Portable Compressors

6.1 Operation of Equipment

The machine shall be operated as for continuous service and at its normal rated working pressure.

Idling Condition

The machine shall be running in the idling condition with the discharge valves from the receiver closed.

Full Speed on Load Conditions

The machine shall be running at the design full speed with the compressor on load, delivering its rated output and pressure. The discharge should be piped clear of the test area or fed into an effective silencer.

6.2 Test Environment

This method calls for an environment which can be obtained only on an open site above a hard reflecting plane. An example of a suitable test site would be an open space of which the central twenty (20) meters are covered with concrete, asphalt, or similar hard material.

Care should be taken that gusts of wind do not distort the results of measurements. A microphone windscreen should be used if it is essential to carry out tests in gusty conditions. A calibration correction shall be applied.

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*Excerpted from "Cagi-Pneurop Test Code for the Measurement of Sound from Pneumatic Equipment," (1969). Compressed Air and Gas Institute, New York, New York.

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6.3 Background Sound Level

The background sound level, when the machine on test is not running, shall be determined at one of the microphone locations to be used when conducting the test. The readings at each location, with the machine running, should exceed the background levels by at least ten (10) dB in each octave band of interest. When the difference is less, corrections should be applied. If the difference between the measured sound and the background sound in any octave band is less than three (3) dB, a valid sound measurement of the machine cannot be made in that octave band.

Octave bands of interest are defined as those where the sound pressure levels produced by the machine are within forty (40) dB of the highest measured octave band level, but in no case are levels below fifty (50) dB considered important.

6.4 Sound Measurement

The following microphone locations shall be used for the test and the prescribed measurements shall be taken:

6.4.1 Microphone Locations

A preliminary survey shall be taken all around the machine at a distance of one (1) meter from the nearest major surface and at a height of 1.5 meters to establish the direction of the maximum overall sound level (A scale). The microphone locations shall be in this direction and in four other directions located at each end and at the center of the sides of the machine.

Two sets of microphone locations shall be used (see Fig. 22):

(a) One (1) meter distance from the nearest major surface of the machine and at a height of 1.5 meters above the reflecting plane.

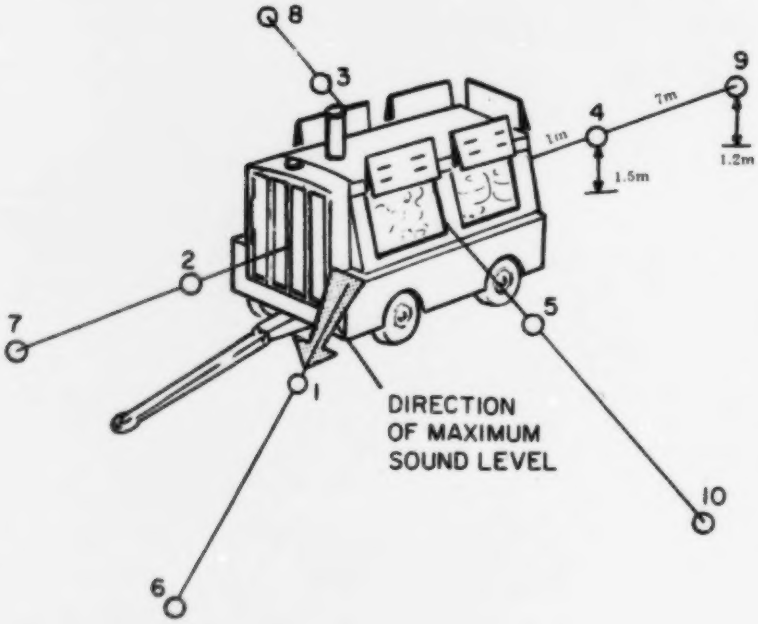

FIG. 22. PORTABLE COMPRESSOR.

(b) Seven (7) meters distance from the nearest major surface of the machine and at a height of 1.2 (1.5 m for ISO 2151-1972) meters above the reflecting plane.

6.4.2 Measurement Technique

Because of the interference between direct sound waves and those reflected from the ground, large errors may occur when strong discrete frequency components are present. Tests shall be made by rapidly [minimum one (1) cycle per second] moving the microphone vertically approximately ±0.3 meter from each location. The microphone shall be held in the position, grazing incidence or perpendicular incidence, in which it was calibrated for flat response.

The period of time during which the measurements are made shall be long enough to allow an average reading to be taken with the slow response setting of the meter.

No reflecting surfaces shall be near the microphone. Observers and measuring instruments shall be at least one (1) meter away from the microphone and the machine under test (microphone must not be placed between observer and machine). Precautions shall be taken to minimize interference of the sound measurement by the operating personnel.

6.4.3 Measurements to be Taken

The following measurements are to be taken: first, at one of the microphone locations for background sound without the machine operating; second, in each of the microphone locations with the machine operating under the conditions of paragraph 6.1:

(a) Overall sound level using the "A" weighting network.

(b) Octave band sound pressure levels using the flat response network.

8.0 Calculation and Interpretation of Readings

8.1 Calculations

Readings should be corrected for background sound. Calibration corrections, if required, shall be taken into account. The average of the corrected sound pressure level readings at the specified microphone locations may be calculated according to the following rules:

8.1.1 Maximum Variation Five (5) dB or Less

If the maximum variation in corrected sound pressure levels is five (5) dB or less, average the sound pressure level values arithmetically.

8.1.2 Maximum Variation Five (5) dB to Ten (10) dB

If the maximum variation in corrected sound pressure levels is between five (5) dB and ten (10) dB, average the sound pressure level values arithmetically and add one (1) dB.

8.1.3 Maximum Variation Over Ten (10) dB

If the maximum variation exceeds ten (10) dB, average according to the equation below:

$$[L] = 10 \log_{10} \frac{1}{n} \left[\text{antilog}_{10} \frac{L_1}{10} + \text{antilog}_{10} \frac{L_2}{10} --- + \text{antilog}_{10} \frac{L_n}{10} \right]$$

where $[L]$ = Average sound level (dBA) (or band average pressure level in decibels)

L_1 = Sound level (dBA) (or band sound pressure level in decibels) at first position

L_n = Sound level (dBA) (or band sound pressure level in decibels) at nth position

n = Number of measuring positions.

8.2 Presentation of Data

A test report shall be supplied and shall give the following information:

8.2.1 Statement that the test was conducted in accordance with the CAGI-PNEUROP Test Code.

8.2.2 Description of the machine, operating conditions, and a sketch showing the test layout and microphone locations.

8.2.3 Make, model, and serial number of instruments used.

8.2.4 Tabulation of test data:

8.2.4.1 Corrected sound level measurements at each measuring point (dBA), and corrected octave band sound pressure levels.

8.2.4.2 Background sound level at one (1) point (dBA), and octave band sound pressure levels.

8.2.4.3 The average of the corrected (dBA), and octave band sound pressure levels (optional).

8.2.5 Plotting of test data: Octave band data shall be plotted for the microphone location at which the highest sound level (dBA) was recorded.

APPENDIX E: EXAMPLE OF CONSTRUCTION-SITE NOISE

Much of the calculations and analysis of construction noise generation and propagation are based on scenarios or models. The use of these general models to correlate predicted community noise with "real life" situations is often questioned.

To provide some "real life" construction noise information, a construction site for an office building was visited during the excavation phase. In Fig. 14 are photographs of the construction site and the equipment present. Of particular interest is the air compressor operating in conjunction with the paving breaker mounted to a backhoe. The large wheel loader operating in the background would intermittently move into the area of the sound level measurements. Figure 23 shows the closest position for the wheel loader along with the positions of the air compressor, backhoe, and paving breaker. During the sound level measurements, the heavy truck (see Fig. 14) accelerated through three-gear selections along the path marked in Fig. 23. Site sound levels are recorded over a 30-min period with a 1.5-min excerpt displayed in Fig. 24. The uppermost sound level time history is for the compressor at idle (81 dBA) with the wheel loader moving in and the backhoe going to a new position. The wheel loader and backhoe increase the site sound level above the air compressor noise at the microphone only when they are in close proximity to the microphone or when they operate at greater than idle load. The wheel loader noise is loudest during bucket rapout (bucket against stops) shown above W.L. on the time history trace (Fig. 24).

The middle trace in the time history shows the paving breaker (P.B.) noise. Peak sound levels for the paving breaker

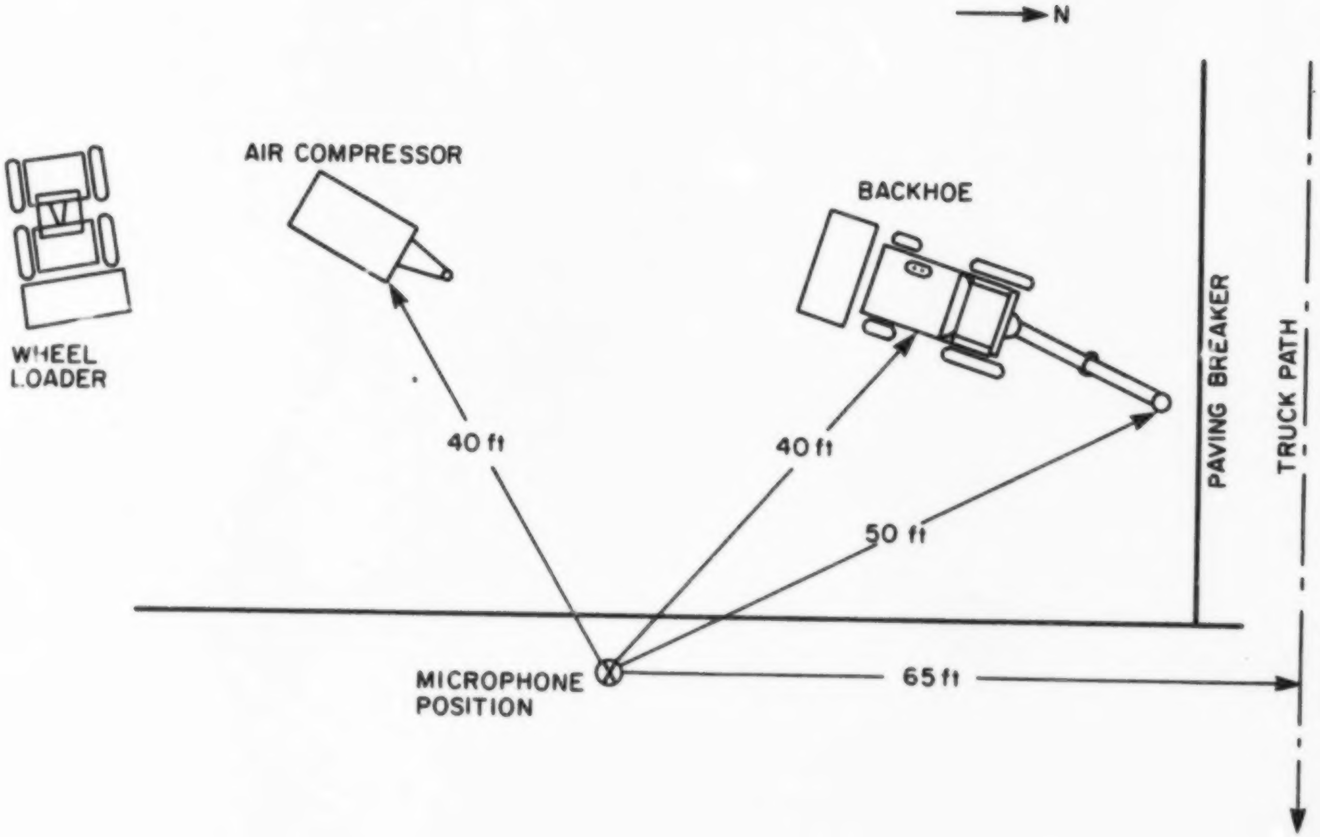
N
AIR COMPRESSOR
BACKHOE
WHEEL LOADER
PAVING BREAKER
TRUCK PATH
40 ft
40 ft
50 ft
65 ft
MICROPHONE POSITION

FIG. 23. LAYOUT OF CONSTRUCTION SITE.

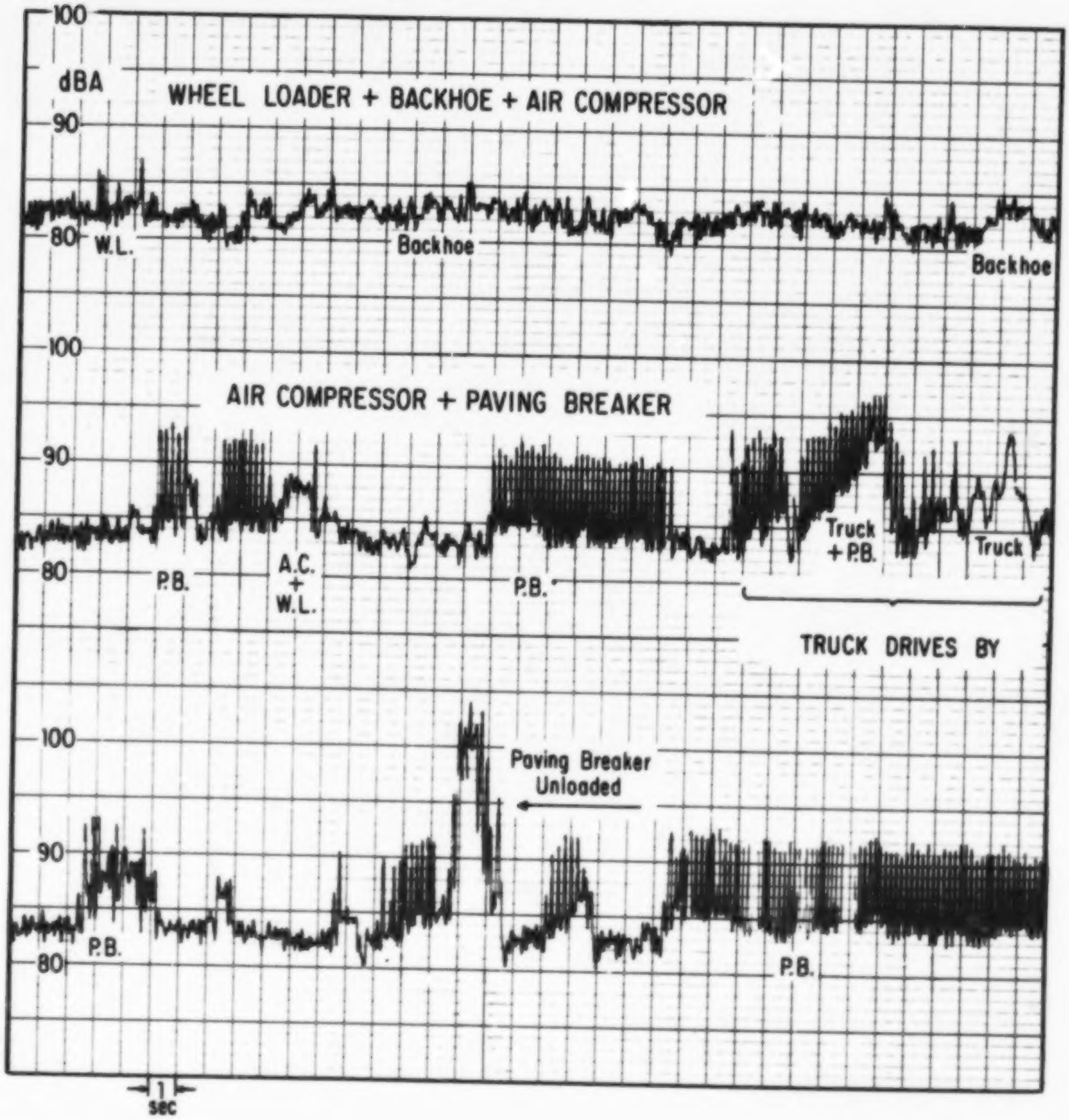

FIG. 24. TIME TRACE OF CONSTRUCTION SITE SOUND LEVEL.

during loaded operation are 93 to 94 dBA. During paving breaker operation, the air compressor (A.C.) cycles to full power mode of operation. Towards the end of the middle sound level track, the heavy truck drove past. Using the equipment displacements in Fig. 23 as a reference, the truck was stopped at a position behind the backhoe. The truck then accelerated past the microphone using three-gear selections. During the first two gears, the paving breaker was operating and obscured the truck noise levels. The influence of truck noise on overall levels even during the paving breaker operation is quite apparent. As the truck shifted into third gear, the paving breaker stopped. The final track shows the truck accelerating away from the microphone with a peak level of 94 dBA.

The lowest track shows the paving breaker and air compressor operating with the backhoe idling. During the recording, the paving breaker was operated unloaded (lifted into the air). The peak sound level is 104 dBA during this period.

To compare the sound levels measured at this site with the various models developed, Table 17 lists the equipment at the site and their associated sound levels. These sound levels are used to estimate the L_{EQ} levels in dB, which are listed along with the fraction of time that the equipment is in use. Comparison of these L_{EQ} levels and use factors with those in Table 15 for office excavation construction shows a degree of correlation between the model and the "real" world. Thus, for this particular construction site survey, the model used to predict community noise levels because of construction equipment would be an accurate assessment of the "average" sound levels and operation at the construction site.

TABLE 17. CONSTRUCTION EQUIPMENT AT VISITED SITE

Description	Sound Level	Sound Level Extrapolated to 50 ft	Estimated L_{EQ} During Operation (dB)	Fraction of Total Observed Time
Air Compressor (Sullair)	85-dBA full power, 81-dBA idle (doors open) at 40 ft	83-79 dBA full power - idle	81	1.0
Backhoe (Hi Dynamics)	85-dBA partial load, at 40 ft	83 dBA partial load	83	0.2
Paving Breaker	93-94 dBA peak, at 50 ft	93-94 dBA	90	0.4
Wheel Loader (Caterpillar)	83-dBA partial load, at 60 ft	85-dBA peak at partial load	82	0.3
Truck (Mack)	94-dBA peak, at 65 ft	96-dBA peak	92	0.1

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